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## ONE: EXECUTIVE SUMMARY

This report presents results from the Picasso Project, a two-year collaborative research project conducted jointly by Philips N.V. of The Netherlands and the Institute for Research on Learning of Palo Alto, California. These two pooled their resources, their interests, and their perspectives to undertake an innovative and much needed investigation into how people in authentic workplace situations actually learn to work with new tools and how tools may best be designed for these conditions.

The project focused specifically on the introduction of interactive multimedia communications appliances into the workplace. The goals and results of the project were, however, more general. The researchers used the specific tools and specific worksites under investigation to explore and critique not only new workplace tools, but also, more generally, new methods, responsive both to corporations and to consumers, for conducting research into and developing these tools.

In the course of the project, the multidisciplinary research team developed an approach to synchronized research and design, called "Reciprocal Evolution." This method is based on detailed exploration of actual worksites before, during, and after the introduction of new technologies. In a continuously iterative process, observations from worksite research inform the design of prototype devices. These new designs are then introduced into worksites, and the new workplace conditions and relations they produce are studied and once again the resulting observations are brought to bear on future versions of the design.

Not only is this approach iterative and incremental, using the new technologies themselves to probe workplace practice, it is also thoroughly embedded in the conditions of actual work practice. It thus produces data whose ecologically validity and generalizability is far greater than that of other research methods—and thus of far greater use to designers and developers.

The body of this report details some of the more important insights into the adoption and use of new technologies in the workplace provided by the project. Among the most significant of these are

the profound, though generally unnoticed contribution made by collective learning and the social infrastructure to learning in the workplace

the importance of the availability of alternative, varied, and negotiable communication channels for people who have to learn and negotiate the uses of new devices

the contribution of collective, shared evaluations of new technology to learning and use

the ways in which technology can support, but also unexpectedly obstruct essential workplace practices such as the management of office meetings and their agendas

the complex role communications technology can play in such essential communication processes as turntaking

It is the conviction of the participating researchers that these and related rich, socially situated insights are important for the future successful design of communications devices, but that they are also generally invisible to conventional research methods.

The report is organized to give the reader a sense of the collaboration, the methods, and the activities of the project; the disciplines and contributions of the participants; and finally, the research, design, and corporate implications of the work. Thus it is also, the researchers hope, a blueprint for future successful partnerships of this sort.



## **TWO: DESCRIPTION OF THE PROJECT**

### **21: Picasso Project**

The Picasso Project resulted from a collaboration between Philips N.V of The Netherlands and the Institute for Research on Learning (IRL). We investigated the learnability and usability of multimedia communication devices that support collaborative work ("cowork"). In particular, we explored how these devices change, enhance, but also detract from established communication and work practices. The Picasso Project is therefore closely related to ongoing research into interactive multimedia communications (IMC) and computer-supported cooperative work (CSCW). The project was developed in the context of the Philips Informational Communication Appliance (PICA) architecture currently under development.

As part of the project's research into the relation between multimedia communication devices and cowork, we studied changes in work practices that emerged as new communication and computational technologies that we specifically designed for the project were integrated into work sites. By establishing long-term relationships with the people whose work practices we studied, we were able to examine the practices in place before the devices were introduced, the ways individuals and groups learned and used the new devices, and the ensuing changes in work practice and organization of work.

This report is not confined to ethnographic studies of work, however. We also address the broader industrial implications of the research. These include new insights into designing and prototyping that result from our evolving understanding of how people learn to use complex technologies. We also outline system platforms and standards that will be needed to support learnable and usable IMC designs in the future.

### **22: The partners**

Philips N.V. is a multinational electronics corporation with headquarters in The Netherlands, which has a strong commitment to industrial research. The Institute for Research on Learning is an interdisciplinary research center based in California committed to research into the fundamentals of human learning.

The ultimate motivation for a commercial corporation to support projects such as Picasso is to develop, introduce, and support commercially successful products. Thus, while Philips came to IRL to learn how to explore the work practices of its market cultures and to understand something about how people learn to use new technologies, it also came to learn how to incorporate this information into the design of future products and how to integrate the underlying theory into its own processes and philosophies of product development.

In particular, Philips wanted to investigate

- advantages of rapid prototyping over designing by prior specification
- implications of the theory that systems should evolve, not only in response to newly available technological opportunities, but also in response to continued study of how current products are changing people's expectations, practices, and desires in the marketplace

For Philips, the findings of the project will contribute to a new approach to product conceptualization and development, as well as to the exploration of a new domain of products and services that view learning as a "way of life and work" and that are designed to support continual learning. One of the central goals of the project, from Philips' point of view, was to generate ideas, suggestions, and conclusions regarding these issues and, more importantly, to demonstrate to the Philips groups involved in development that these points of view are crucial. This portion of the Picasso Project work is described in detail in section 6.3, "Reciprocal Evolution and the Corporation."

For IRL, the findings of the project will contribute to the advancement and refinement of IRL's core research problems. Contributions include:

- investigation of the nature of workplace conversational and interactional practices and how these change with the introduction of new tools
- understanding of the contribution tools make to such changes
- insight into the ways in which new learners can enter into a culture of evolving practices and "appropriate" its tools
- development of co-design strategies and methods

### **2.3: Innovative commitments**

The Picasso Project involved an exploration of current concepts of information, communication, and learning. In our approach to this work, we had two innovative commitments that reflect interests of both Philips and IRL. (These are explored in greater detail in part 3.) These were:

- a focus on the relatively neglected social organization of work and learning, rather than the more common focus on technological or cognitive organization
- the use of the method of Reciprocal Evolution, developed by this project, which relates research and design activities through a continuous feedback loop

#### **2.3.1**

##### **The social organization of work and learning**

Even when individuals work alone, the concepts they use are the product of a deeply social, collective, constructive process. These are shared and distributed throughout communities and learning is assessed as the ability to use these concepts in community contexts. We refer to such communities built around shared practices as "communities of practice" (Lave & Wenger, 1991).

With the growth of new technologies, particularly those that used existing communities, people more frequently find themselves engaged in practices and communication activities that are particularly hard to understand until new conventions become stabilized through social construction. Thus, the Picasso Project studied the development of necessary communications conventions. To this end, it focused on people working and learning in real world settings. This is a departure from much of the research in human-computer interaction (HCI) which highlights (or exclusively considers) cognitive aspects of human-tool interactions.

#### **2.3.2**

##### **Reciprocal Evolution: Integrating research and design**

In order to understand the contexts in which conventions and learning are constantly evolving, as well as to find ways to incorporate this understanding

into philosophies and process of product design, the Picasso Project made use of a research and design method called Reciprocal Evolution. This is described in detail in section 3 of this report. In brief, Reciprocal Evolution consists of three kind of work:

- use of findings from basic research to motivate analysis of data
- study of the work practices of work groups
- derivation of design implications from this observation and research

Each activity influences and is influenced by the others. Basic research in a number of fields suggests methods and categories of analysis. The analysis suggests hypothesis about new designs. New designs create new work practices, which themselves require study, and whose study provides new contributions to basic research. This perspective is innovative in that the day-to-day work of a research project requires the cross-fertilization of ideas across disciplines, and it affords a significant opportunity for research to influence design, and in turn, for design to influence research.

The participation of Philips research scientists in the Picasso Project insured that the results of both innovative commitments—the social-organization perspective and Reciprocal Evolution—could find their way back to the product design and development processes within the corporation.

## **2.4: Project members**

*Christina Allen*, Manager of the Picasso Project and IRL Research Scientist, has a background in product design and computer science, with a research emphasis on the cognitive and social processes of designing and learning to use technologies. Her research has focused on the organization and communication of both large and small workgroups.

*Charlotte Linde*, IRL Senior Research Scientist, is a linguist specializing in discourse analysis. Her research centers around the use of language in a variety of social and technological settings, including investigations of the role of ineffective communication in commercial aviation accidents, and the effects of social and technological structure in the work of police helicopter crews. Currently, her research is involved with the question of what makes a new computer technology learnable and what the effects are of the introduction of a new technology to the work practices and social structure of a work group. She

is also doing research on the use of life-story narrative in the social negotiation of a self, and on the use of documents, procedures, and informal narrative in the construction of institutional memory.

*Roy D. Pea*, IRL Senior Research Scientist and Consulting Professor at Stanford University, is a cognitive scientist with special interests in integrating research and the design of effective learning environments for science, programming, and multimedia computing. He has published a book and many articles and reports on learning with computers, cognitive science, cognitive development, and language learning.

*John H.M. de Vet* is from the Institute for Perception Research (IPO), part of Philips Research Laboratories in Eindhoven, The Netherlands. He has a M.Sc. in Electrical Engineering from Eindhoven University of Technology. His research interests include the design of effective human-computer interfaces, prototyping, knowledge representation, and the interrelation of system design and system use.

*Rob de Vogel* is a systems developer within Advanced Development of Philips Information Systems in Eindhoven. He has been working on the design and development of several products for the support of office work and on studies of communication devices. His work interests include interactive multimedia communication and the social, technological, and commercial aspects in the design and introduction of complex technologies in the home and the workplace.

## **25: A brief history of the Picasso Project**

The project covered three years' work. The first year was devoted to defining the project collaboratively with IRL and Philips and designing and implementing Picasso 1.0 (the first prototype multimedia communication software). The second year comprised the refinement of Picasso 1.0 for installation, the establishment of a first Picasso research site and research agreements, and the collection and analysis of field video recordings of Picasso 1.0 in use. At the end of this second year, Rob de Vogel returned to Philips and John de Vet joined the project. Christina Allen became project manager. During the third year, the integrated empirical, theoretical, and design activities led to the definition and programming of a new prototype, Picasso 2.0, and its installation in early 1991 in both the first research site and a new, second site. Culminating activities in the third year included analyses and reports of the results of the research with Picasso 1.0 and Picasso 2.0; the consequent design (but not implementation) of

Picasso 3.0; the preparation of final reports, papers and chapters for publication; and the conducting of workshops reviewing the project's methods and findings at Philips.

### 2.5.1

#### **Phase 1: Development of IRL–Philips relations**

In the first phase, an IRL–Philips contract was developed. This sketched the relevant key themes of IRL's work. The following sections from the contract lay out the nature of the cooperation:

The new project Philips and IRL are developing explores central issues concerning the design, introduction and use of interactive, personal information appliances—appliances that promote richer learning and communication.

[Research questions] demand a principled understanding both of the situated nature of human communication and appropriation and the technological design and social uses of multimedia communication artifacts.

The project is intended, therefore, to initiate and undertake a far-reaching exploration of current concepts of information, communication, and learning.

In particular, but not exclusively, it will absorb insights gained through the work being conducted under IRL's Glass-Box Theme and in such projects as the Mediaworks Laboratory.

### 2.5.2

#### **Phase 2: Articulation with IRL themes**

The actual project began at IRL during spring of 1989, with the arrival of Rob de Vogel. In the beginning, the project's planned work was articulated in terms of three research "themes" defined in the work of IRL. Together those themes comprised IRL's view of learning at the time. (They did not, however, preclude the development of other themes.) The themes (described in detail in appendix 1) were:

- glass box technology
- social construction of understanding
- situated learning

Following the conceptual articulation of Philips projects with the IRL themes, the Picasso project was planned with the collaboration of Roy Pea and other IRL

scientists such as Gitti Jordan and Susan Stucky. Initially a five-year plan, this was completed in May 1989. The project proposal noted:

The Picasso Project will perform research on the learning and use, both in the workplace and at home, of communication devices supporting the performing of collaborative tasks using interactive multimedia communication devices. An examples of such communication devices is the future PICA architecture currently under development at [Philips].

Given the nature of these IMC devices and the markets that are foreseen for Philips in the near future, the following topics in particular require extensive investigation:

*Bootstrapping:* Once a user has reached a certain level of skill ("passed the critical threshold") in using PICA, the system can be used to communicate with other users and in this social context the user can augment his or her skills and take better advantage of the system. Only after mastering "on his or her own" some basic skills, can the user use PICA and the network "behind" it, to augment those skills.

*Growth path:* PICA is a family of communication devices rather than a single one. As the infrastructure that forms the basis for the communication channels between any PICA grows from traditional analogue telephone lines to Integrated Services Digital Network (ISDN), or even wide-band networks, the range of applicable communication media will increase, resulting in a wider range of possible "applications." In other words, there is a growth path from voice to interactive video communication. This has to be reflected in the work that will be done for Picasso. The research must select some representative steps on this path.

*Media:* PICA will not function in a vacuum. The media in the "multimedia interaction" each has a history of use and each PICA user will have experiences with and expectations from interaction using these media. Conventions and standards have grown which will affect PICA, and to some extent will be affected by PICA. There are important lessons to be learned from the usage of the telephone, the way fax-machines are introduced and used, the failure of video conferencing, routing problems in e-mail, and other media-originated problems. Although there is not much activity that aims at researching the merging of media into multimedia, the analysis of experiences with each individual media is invaluable for Picasso.

*Separations in space and time:* Communication devices can span separations in both space and time. Although Picasso should and will address both, the spanning of separation in space (so person- to-person communication using some communication device) has priority in the research. Mainly because, from the technology point of view, in most cases the support for "separation in space" precedes the support of "separation in time." But also because, from a research-on-learning point of view, the solution to the latter requires a thorough understanding of the problems of the former.

### **2.5.3**

#### **Phase 3: Development of prototypes and selection of research sites**

During the summer and fall of 1989, work took place to define a multimedia communications prototype that could be used to carry out empirical studies for the project.

That prototype, Picasso 1.0, was installed during late 1989 in a collaborative work site, Glorious Graphics (GG), where two graphic designers worked fifty miles apart. During Summer 1990, we worked to develop a second version, Picasso 2.0. We also established a second research site at the Housing and Education in Living Project (HELP)<sup>1</sup>, a private welfare agency serving the mentally retarded with many sites scattered throughout the region. We began to study their existing work practices and communications in anticipation of introducing the new prototype. During fall and early winter of 1990-1991, a refined design of Picasso 2.0 was prototyped, tested, debugged, and a manual written. In February 1991, this second prototype was installed in both research sites and data collection and analysis continued. (For more on the sites, see section 4.1.)

### **2.5.4**

#### **Phase 4: Aggregation of emergent issues**

In a fourth phase of the work, the empirical observations of cowork using the multimedia communication tools created led us to look more closely at the issues which emerged from the application of the concepts of glass box technology, social construction of understanding, and situated learning. We defined a set of observational issues that included:

- augmentation channels
- bootstrapping
- collective exploration
- communication veils
- coordination theory

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<sup>1</sup> Names of the organizations we studied have been changed. Participants' names have been replaced by initials.



- crystallization
- media shifts
- methods
- participatory design
- prototype design
- representation quality
- work-practice evolution

### **2.5.5**

#### **Phase 5: Articulation project topics**

Finally, in the fifth phase of our work, we came to select a foundational set of research and design topics—the most distinctive and the broadest in implications—for the work we had completed. These were:

- collective learning
- communication channel use
- social negotiation of attitude toward technology use
- meeting and agenda management
- ongoing activity and the structure of turntaking

This group of topics is more socially focused, and consequently less technically and cognitively focused, than our first interpretations of the data. Some of the emergent issues were then arranged under these topics. We explore both in detail in sections 5.1–5.5.

During this phase and based on what we had learned so far, work also began on the specifications and interface for Picasso 3.0, although there was not time to implement a working prototype. (See section 6.2.2.)

## THREE: RECIPROCAL EVOLUTION

### 3.1: Overview

The quality of a design is not determined by technical factors alone, nor can it be understood solely by cognitive analyses of users or tasks. Social organization of work, tool learning, and tool use in real-world work activities must play equally important parts in evaluating a design. Reciprocal Evolution<sup>2</sup> is a research and design method developed from this insight.

Reciprocal evolution involves continual reconsideration of:

work practices: how people reorganize work practice when new technologies are provided; how technologies assume a role in day-to-day work and interaction; how use differs from designers' intentions; and how tools make new organizations of work and communication possible

design implications: how to generate and review new designs in response to observations and conversations with practitioners about the ways a system can be better used and learned; how technologies can clarify issues of communication and learning

basic research: how issues that arise around technology learning and use affect areas of theoretical research in learning, work practice, communication, and systems design

In sharp contrast to a technology-driven approach, a use-based approach like Reciprocal Evolution must be committed to the evolution of the technology beyond prototyping and new versions. Technology is no longer simply the object of development and marketing. A new design must also be thought of as a probe with which to investigate and stir up work practices, to suggest new research directions. In this way it can extend understanding of issues involving practices with technologies, including:

how people adapt their existing practices to integrate new technologies  
how they use and change technologies to support their existing and desired practices

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<sup>2</sup> This topic is more fully developed in Allen, 1991 (Picasso Publication 1).

Reciprocal Evolution is thus not a method just to design a tool before it is released to the public. Rather, it is a method that sees such releases as data-collection opportunities for a deeper understanding of how tools are used.

### 3.2: Assumptions and method

One of the fundamental assumptions of Reciprocal Evolution is that to understand how people learn and use a technology, researchers must understand the work practices before the technology is brought into that work setting. The ways in which people work and the kinds of tasks they need to do influence what they choose to learn or are willing to learn. It also influences understanding that they bring to the new technology. Furthermore, to understand the effects of the new technology, it is not enough to study how many of the functionalities the participants have learned to use. Rather, it is necessary to trace the changes in work practice which have come about as the result of the introduction and learning of the technology.

The way people describe their work practices is very different from actual activities. (See section 4.2.). Video-based analysis can demonstrate what work practice is like.<sup>3</sup> This allows researchers to address questions such as:

- what is a "naive" user?
- what are work environments like?
- what are the actual work practices of participants?

Most designers do not know what "naive" users look like. They tend to remember themselves as naive users, though even then they were probably light years ahead of the questions, assumptions, and fears of most actual users. We found, in showing tapes of our participants, that designers and cognitive scientists are consistently shocked by what they view as users' incompetent and inconsistent behavior. For example, they are surprised that when a program does something which the users find inexplicable, users often make no attempt to diagnose what happened. Many users tend to assume that on occasion, a computer will do something puzzling and it is not worthwhile to try to come up with an explanation. Even if we ignore the methodological problems introduced when researchers

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<sup>3</sup> Issues discussed in this section are developed in Linde, in press-a (Picasso Publication 2).

criticize participants, the fact remains that designers often have to design for the very people whose behavior they often either cannot sympathize with or comprehend. Yet some designers seem to understand their users as little as the users understand their technologies.

Similarly, designers often do not know what work settings look like, or under what conditions new technology is learned. We found that participants learn the new technology in conditions that continually divide their attention. For example, in one session we filmed, one of the participants at the HELP site is on the telephone with her learning partner attempting to learn Picasso. She is also sharing her rather small office with three other workers, who come in and out, talking with one another behind her. The video data show that although apparently engrossed in the Picasso task, and with her back to the other workers, she also monitors the others' activity in the office and responds to their conversations and activities. This example indicates the type of conditions under which workplace learning is likely to take place. It may or may not be better to have the two people learning Picasso isolated in a white classroom, away from these distractions. Nevertheless, as a practical matter, these are not the conditions under which people are likely to learn new office technologies. Thus designers must consider whether their designs are learnable under the actual, almost chaotic conditions of ordinary working life.

### **3.3: Rapid prototyping**

It is our conviction that use *is* design. Hence studies of technology in use should be a regular and on-going part of any design effort. Unlike other approaches to design, this approach requires study, before the technology is designed, of the social situation in which it will be used. This allows researchers to understand the evolution of work practices before and after the technology is introduced. Moreover, this information is provided in real time so that it can affect the design of future generations of technology, which requires the rapid prototyping.

Rapid prototyping has both opportunities and drawbacks. The opportunities come from the ability to implement design ideas quickly, to put them into real world settings, and to develop a better design rapidly by incorporating feedback into the design. For Reciprocal Evolution, rapid prototyping is crucial.

The drawbacks of rapid prototyping include the nature of prototyping languages, which are difficult, if not impossible to translate into product code. Because

prototypes are written in high-level languages and make use of other systems, they can be slow and often must be designed in ways that do not make optimal use of the platform or software opportunities. Consequently, in the prototype phase, less-than-optimum performance can be an extraneous issue in trying to understand how the product can be learned and accepted.

### 3.4: Research requirements

Picasso researchers contributed diverse expertise to the Reciprocal Evolution paradigm. First and foremost they collectively produced an essential interdisciplinary focus on the nature of communication, drawing on anthropology, cognitive science, design, ethnography, interaction analysis, linguistics and semiotics.

These basic research perspectives led us to carry out empirical work consisting of task-oriented studies and detailed analysis of the interaction of users with the communication and computing devices. Within this overall framework, we paid particular attention to the following requirements:

ecologically valid data: We investigated, as far as possible, naturally occurring situations in which the technology was used, rather than laboratory situations, which share too few of the properties of other real work settings.

study of existing practice: We examined workers' existing practice, before the introduction of new technology. Current interactions provide both data for tool design and the standard case, against which a new technology is evaluated by users.

multiple methods: We used a broad set of methods for collecting data, because various types of data were needed. Investigations of collective learning, for instance, required very detailed and specific data on the interactional "appropriation" or achievement of "ownership" of a piece of new technology. Video was able to provide this sort of data. On the other hand, structured interviews provided information on how such a piece of technology became "encultured" as an unremarkable and routinely used object in the social and cultural texture of cowork.

qualitative inductive research: The appropriate research framework for our studies was qualitative and inductive, rather than a quantitative hypothesis testing. Reciprocal Evolution needs to identify the relevant variables—the resources and constraints whose presence shapes people's interaction with technology. For this, a rigid hypothesis-testing approach would have been inappropriate.

### 3.5: Reciprocal Evolution and other design perspectives

Basic science and design usually present two opposing extremes in analyses of human–computer interaction. System design and HCI communities range between these extremes. Yet there is very much more to the evolving functions of technology in work practices than either the cognitive interface between the computer and the "user" at one extreme, or the system design perspective driven by institutionally defined work task requirements, at the other. In both perspectives, the machine plays too large a role in the analysis, when in fact it is but one element shaping the work life of workers and communities of practice. Reciprocal Evolution attempts to connect these opposing poles through the mediation of careful observation of actual work practices. These practices involve the use and synthesis of analyses from each pole and from the whole range of activities that lie in between them.

Reciprocal Evolution does not seek universal principles as in science, or single particulars as in participatory design. Rather it explores design dimensions from recurrent problems emerging out of the interdisciplinary microanalyses of videotaped records of situated work practices. These dimensions provide fertile invention "materials" for new tools as well as salient themes for looking at work practices involving other tools.

The strategy does have general applicability, particularly for sites where participatory design is not possible or where broader design implications are sought from instances of user-centered system design. Worksite observations of how these technologies are used across locations may provide both specific and general information about the work practices and the specific technology.

While we recognize that the relative prominence of particular Reciprocal Evolution topics in our work depends in part on the worksites we chose to study—focus on quality of representations, for instance, which is important for the graphics design firm we studied, would be less pressing for banking work—we nevertheless argue that more is to be gained by attending to general design dimensions emerging from the complexities of worker interactions in even a few collaborative worksites, than in trying to "tune" a specific tool to fit a specific work environment as is done in most participatory design work.

Reciprocal Evolution stands in clear contrast to three other conventional perspectives on design:

- engineering perspective
- cognitive science perspective
- participatory design perspective

### **3.5.1**

#### **Engineering perspective**

Reciprocal Evolution is distinct from the usual engineering orientation of many industrial development laboratories. These engineers look at the new functionalities made possible by the technical capabilities of new computers and communication devices, and, with very little consideration of the contexts of use and work practice, create designs and products that pile feature upon feature. Telephone answering machines and VCRs are among the most dramatic examples of the engineering orientation, which has unfortunately often resulted in devices that are difficult to learn, difficult to use, and thoroughly ill-suited to accommodating, much less augmenting actual work practice.

### **3.5.2**

#### **Cognitive science perspective**

In relation to cognitive science, we find some overlap between Reciprocal Evolution and Carroll's (1990) approach to minimalist instruction for practical computer skill. We are particularly sympathetic to his emphasis on the need for a designer to work much more with what learners do spontaneously to find meaning in their learning activities with new systems.

Nevertheless, our approach to design differs from Carroll's in two fundamental respects. First, whereas Carroll focuses on the first learning of new tools, we are concerned with continuing learning of users over the life cycles of their work tasks. Second, whereas Carroll's is fundamentally a laboratory–experimental paradigm, we find it essential to observe the rich resourcefulness of learners' practices and social interactions around the technologies in their workplace. It is hard to see how experimental methods can tap either Lave and Wenger's (1991) rich notion of learning as participation in communities of practice or the resourceful innovations and work-situated sense-making workers reveal in their mutual adaptations of work tasks and tool uses. For this reason we consider

that ethnographic studies of situated work practices with tools and prototypes to provide more fertile data for invention and design than laboratory studies.

We find the theory-based design guidelines for human-computer interfaces offered by Newell and Card (1985) deeply problematic. While their emphases on the hierarchical structure of goal-oriented behavior in human interaction define a paradigm aimed at leading to efficiently fast and low-error human performances, these information-processing system considerations are too impoverished to suggest promising directions for design and invention of tools in the first place. They too ignore the creative contributions of users.

### **3.5.3**

#### **Participatory design perspective**

Participatory design methods have been developed by several research groups to address many of the inadequacies of engineering and cognitive science perspectives. Participatory design does examine real work practices, and in such pioneering work as that of Ehn and Bødker (e.g., Ehn, 1989), collaborative teams of workers, systems designers, management, and union jointly envision future workplace scenarios. Importantly, this perspective also provides concrete examples of design arising from the application of participatory design processes.

Participatory design has been designed, however, as a method primarily for fine-tuning specific technological tools for particular work environments, and with significant union involvement (e.g., see Bjerknes, Ehn & Kyng, 1987; Ehn, 1989; Suchman, 1988). We can find little evidence of how this collaboration works from the point of view of the different participants. In other words, how is the democracy now evident in the behaviors, beliefs, and so forth of the participants affected after the designer leaves? Who manages, updates, re-writes the technology without the intervention of democracy-minded computer scientists? An analysis of the distinctive pressures on each of the parties to shaping the collective work they are doing in participatory design is needed to show how this collaboration between designers and the shop floor employees is any different from any other institutionally instigated event.

The social work of collaboration on the part of participatory designers with workers paves the way for the introduction of site-specific new technology. In our opinion, such design strategies would be unlikely to generalize to other sites. It is thus removed from the scientific objective of seeking out general patterns. It is "pulled" too much by solving the design problems for fitting a technology to



work practices for the specific case, and leads to the relative abandonment of a search for generalities. We find this problematic because it loses the iterative use of information from work practice feeding back into design and research for the next generation of systems.

## FOUR: PROJECT ACTIVITIES AND PROTOTYPES

### 4.1: Site choice

The study of the actual use of our designs took place at two sites—GG and HELP (see section 2.5.3). These were workplaces that had an obvious use for the functionalities offered by Picasso. In both sites, the computer abilities of participants covered a wide range.

GG is a two person graphic design firm. When we came to them, the two partners of the firm had been working together for three years. Initially, they had lived within walking distance of one another. Face-to-face meetings were easy to arrange. Two years before we arrived, one partner had moved 50 miles away. This separation necessitated more elaborate phone meetings and the exchange of documents by fax, mail, messengers, etc. Indeed, difficulties in exchanging documents formed one reason why they welcomed the chance to participate in this project: they hoped it would give them access to innovative communications technology.

Both partners were relatively skilled computer users, using a variety of graphics and desktop publishing programs in their work.<sup>4</sup> In addition to their current use, they saw learning of new programs and equipment as an ongoing part of their professional life. They had a wide variety of sources of information and help available to them, including friends and professional associates, their spouses, and the resources of the Berkeley Macintosh Users' Group.

HELP, is very different—particularly with regard to technological expertise and support. HELP is a small private welfare agency that finds, renovates, and manages housing for the developmentally disabled. The particular division we focused on supervised client training and housing. It consisted of a supervisor, her assistant, the housing manager, and a number of case workers. The supervisor and her assistant spent quite a lot of time driving between two sites

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<sup>4</sup> Including Adobe Illustrator 88 1.5, Adobe Type Manager, Aldus PageMaker 3.0, Aldus PageMaker 4.0, Aldus FreeHand 2.0, Manhattan Graphics Ready,Set,Go! 4.5a, Manhattan Graphics DesignStudio 1.0, Claris MacDraw II, Claris MacWrite II, Silicon Beach Software SuperPaint 2.0, Microsoft Word 4.0.

11 miles apart. They therefore welcomed the possibility of using fax- and file-transfer functionalities. Some of the participants had used Apple IIs, some have never used a computer, some used Macintoshes. Those who were currently using computers used Microsoft Works for word processing and spreadsheets. They did not have the kind of distributed help available to them that GG had.

## **4.2: Data**

The primary method of data collection was videotaping of actual learning and work sessions at the various work sites. As a supplement to this, we also did audio and videotaped interviews with participants about the nature of their work, and we collected sample forms, documents, and so forth.

### **4.2.1**

#### **In-situ videotaping of work sessions**

In order to understand the nature of the participants' pre-existing work practices, our general strategy for collecting data was to film the work at the site in question before the introduction of Picasso. We then filmed one or more learning sessions in which users explored and learned Picasso. Finally, we filmed successive work sessions with Picasso to discover both how learning developed and work practices changed as a result of the use of Picasso. Filming schedules were arranged to allow for a time-slice sampling of the participants' learning and use of Picasso. Although it might have been desirable to film continuously for several weeks, the size of the project—three-and-one-half fulltime people—made this impossible, both because of the time involving in the filming sessions, and more importantly, in the amount of time that it takes to analyze so much data. (It is easy to film; it takes thought and cunning to avoid drowning in the filmed data.)

We used 8 millimeter video cameras to film prearranged work sessions. Shots were designed to capture the computer screen, the person, and when possible the person's interaction with other artifacts in the office. In filming HELP's work, we also used Aura Systems' ScuzzyGraph (a color display controller for the Macintosh SE or Classic) to capture the entire record of the computer screen. We could not use this at GG, since ScuzzyGraph would not run on the machines the GG members used and there was no other NTSC video output available.

As much as possible, we tried to make the Picasso sessions close to the situation of an actual customer using a new product. This required the camera operator to stay out of the learning process and not to answer participants' questions about the technology. This sometimes meant that that camera operator had to focus the camera, turn it on, and leave the room, so as not to be available as a learning resource. We found that it was not possible for the camera operation to refuse to participate in the learning situation, since whenever people perceive that a learning resource is available to them, they quite insistently try to use it.

#### **4.2.2**

##### **Interviews**

In addition to videotaping, we also conducted ethnographic interviews with the participants. This kind of interview is useful for asking questions about background matters that will never come up in an actual work session. For example: what kind of prior experience has a person had with computer technology, what are the government regulations governing the way a particular form is handled, who normally does the bookkeeping, and the like. This kind of interview can not be used to determine actual details of work practice. Research has shown that the way people describe what they do is very different from the way they actually do it. The description tends to reflect the way they think it should be done.

### **4.3: Prototypes**

The project was designed to explore issues concerning the design, introduction, and use of IMC devices. These technologies can support both continual learning and rich communication. Thus the Picasso prototypes served two purposes: they were research tools put into sites in order to *study* learning and communication; and they were advanced communication prototypes designed to *support* communication and learning.

In this section, we describe the rationale behind Picasso 1.0 and 2.0. We discuss the evolution of the first into the second in terms of what we learned from the research sites. Due to the limitations of our rapid prototyping environment, not all of our understanding from the observation and analysis process could be

incorporated into these prototypes. (For the design and rationale of Picasso 3.0, which was never implemented, see section 6.2.2.)

#### **4.3.1**

##### **Picasso 1.0**

Picasso 1.0 was developed in order to simulate PICA, the personal information system under development at Philips. Intended to be a low-level communication device, it was in fact a computer-based fax-machine with minimal system requirements: computer, scanner, fax-modem, with rudimentary text and graphics editors. It was designed to create, store, send, and receive text, graphics, and scanned images over an ordinary dial-up telephone line. This allowed two participants to share graphical objects on their computer screens. Other communication functions—a telephone answering machine, databases access—were considered but not offered because they could not easily be integrated in a prototype. To allow participants to talk while working with Picasso, we put in a separate telephone as part of the research design.

By using the fax-modem as an ordinary data modem for file transfer, it was in principle possible to transmit arbitrary computer files. Unfortunately, although sending was indeed possible, the receiving modem could not automatically be signaled to switch its operation from fax-modem to data-modem as appropriate. We thus had to choose either fax- or file transfer. We opted for fax transfer, since that gave our test sites the ability to communicate with other fax-machines. Consequently, file transfer was not incorporated in Picasso 1.0.

The Macintosh platform was chosen since it offered a low-cost solution for a prototype that could be placed at our test sites. A HyperCard application was written to handle setting up fax connections, scanning, file management, and storing, retrieving, and printing of information. The design deliberately inhibited access to other applications on the Macintosh. Even the menu bar was hidden as soon as Picasso 1.0 was started. Picasso 1.0 was not intended to run while other applications were running.

##### ■ 4.3.1.1 *Functional description of Picasso 1.0*

Picasso 1.0 communication is centered around projects, each project being a collection of HyperCard cards. A card can contain scanned images, text, and graphics. The top level in Picasso 1.0 is called the Workbench (fig. 1).

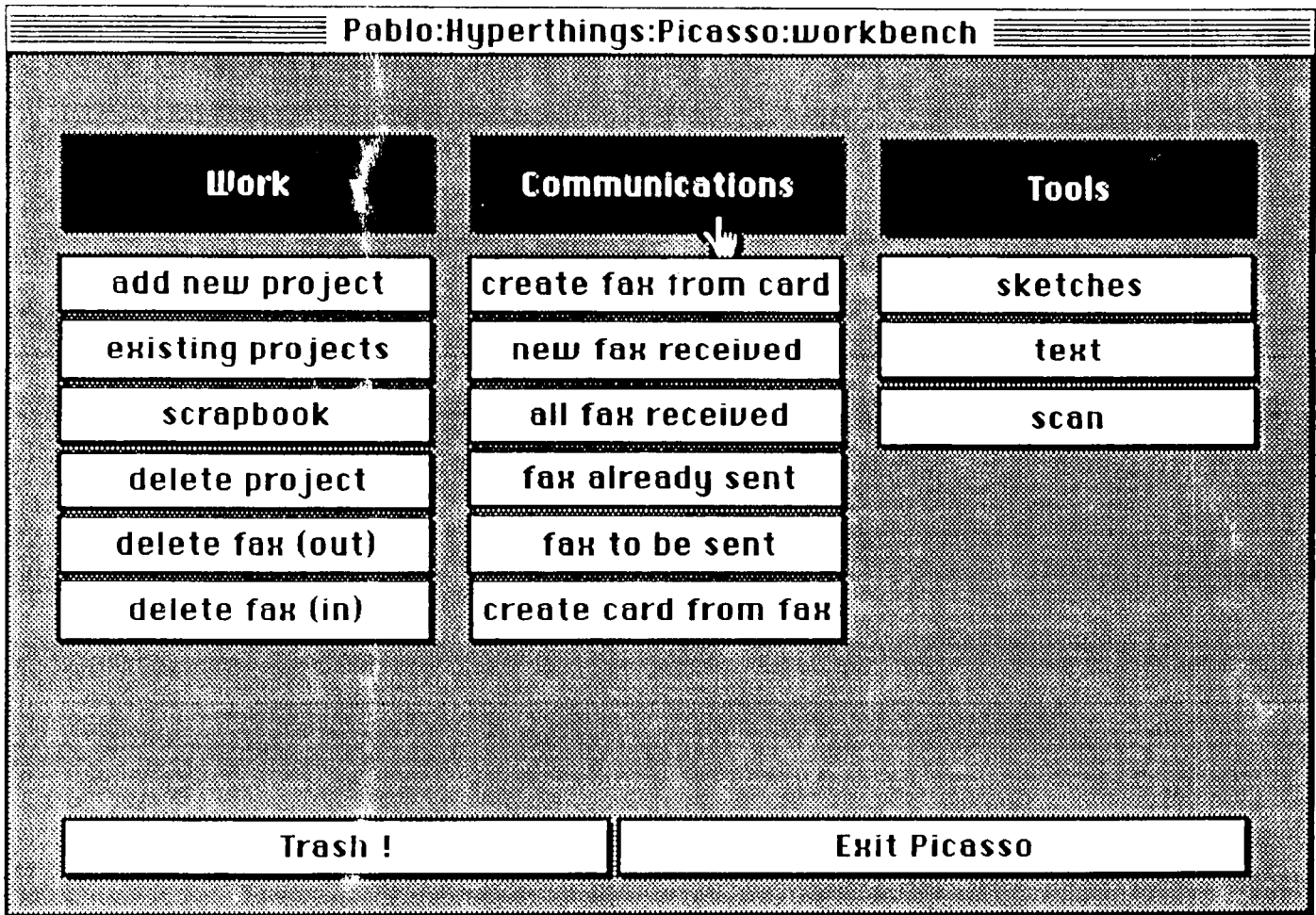


Figure 1: The Picasso 1.0 Workbench with all three menus opened

All communications begin at the Workbench and all other applications are launched from it.

The Workbench distinguishes three main functions:

Work: This allows the user to manipulate (add, edit, and delete) projects. The scrapbook contains cards that are not part of an existing project and can be used to store scanned images or edit existing cards temporarily. Scheduled (or pending) and received faxes can also be deleted via the work function.

Communications: This supports the sending and receiving of fax documents and their conversion to and from cards. Fax scheduling itself has to be done manually rather than automatically, since Picasso 1.0

only opens the fax document with Abaton's InterFax program. Fax documents are automatically compressed before they are stored. The fax transfer itself is a background process and therefore does not interrupt any ongoing work.

Tools: This offers a simple tool for each type of data on a card. The HyperScan function is used for scanning, and HyperCard's tool palette is made available for text editing and drawing (sketching).

Three pull-down menus control the three main functions. In figure 1 all three menus are opened and the menu names are white on a black button.

Existing projects are reached via the menu button with that name. Each card in a project contains some control buttons (fig. 2.).

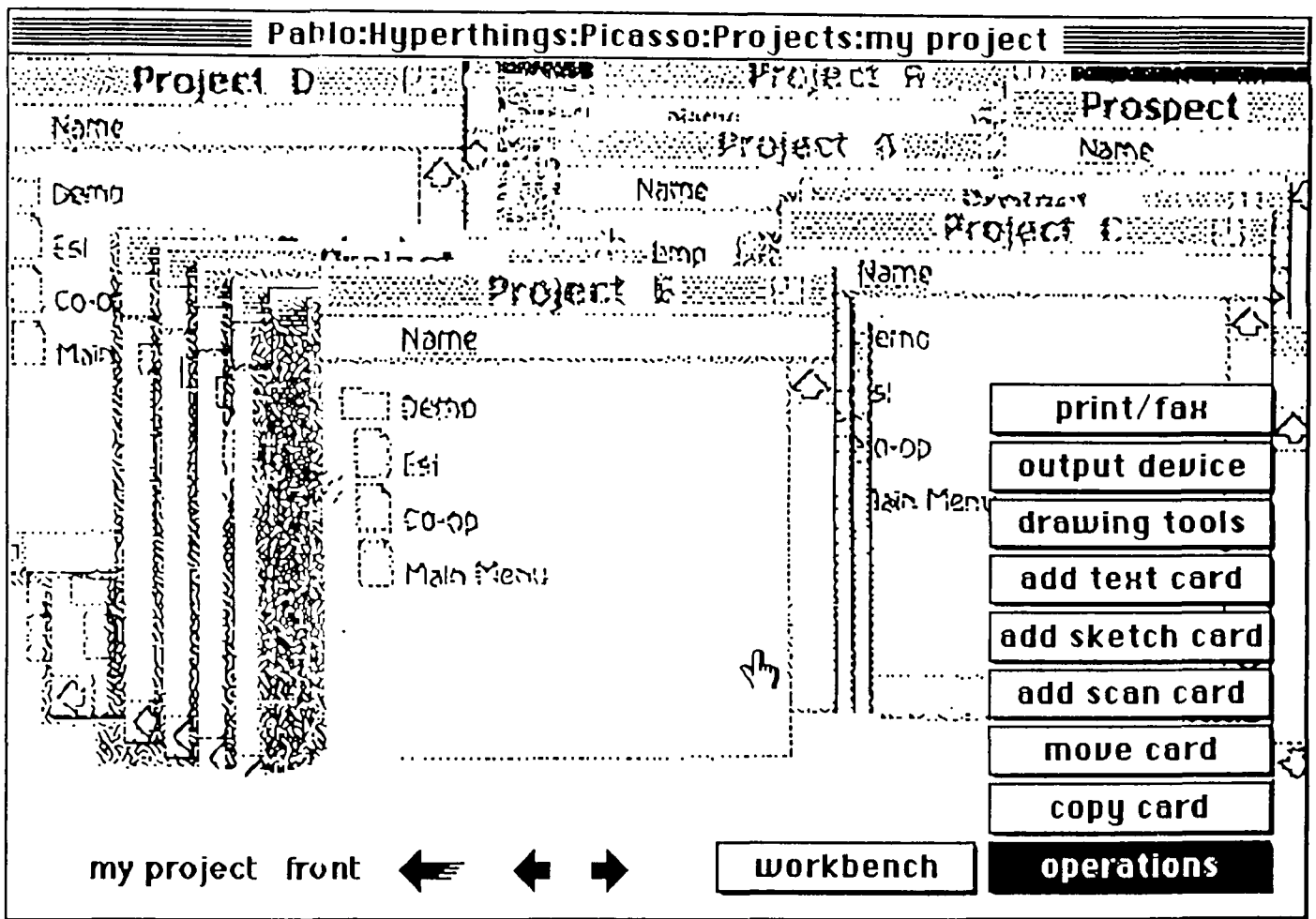


Figure 2: A project card in Picasso 1.0 with operations menu opened

The three arrow buttons allow the user to browse through the project (i.e., move to the first, previous, or next card in the project). One button lets the user return to the Workbench; another contains all the card operations (editors and card manipulators). In addition, a keyboard-button combination gains access to on-line help.

■ 4.3.1.2 *Technical description of Picasso 1.0*

From a technical point of view, Picasso 1.0 is a HyperCard stack, or more precisely a collection of stacks. HyperCard is a hypertext system (Conklin, 1987; Bigelow, 1988) for the Macintosh that is particularly suited for prototyping



highly interactive applications (Apple Computer, 1989; Goodman, 1987; Williams, 1987). Picasso 1.0 uses Abaton's InterFax program as its fax communication tool (Abaton, 1989) and HyperScan as its scanning tool. A complete Picasso 1.0 machine consists of an Apple Macintosh equipped with keyboard, mouse, hard disk, 1MB of RAM, plus the Apple Scanner, and Abaton's InterFax modem (a 4800 baud fax card for CCITT T.4, group 3, compression).

#### **4.3.2**

##### **From Picasso 1.0 to Picasso 2.0**

Based on observations of its use, there were considerable deliberations about new functionalities when we redesigned Picasso. Analyses and discussions centered on:

- system openness
- system primitives
- basic information units
- file transfer
- mail scheduling and notification
- screen sharing
- simple scanning
- application identification
- Macintosh conventions

##### ■ 4.3.2.1 *System openness*

Here consideration focused on whether or not to integrate work tasks and communication tasks. We found that users preferred their own tools for editing text and graphics over the primitive editing tools offered by Picasso 1.0. In general, we concluded, even with more advanced editing tools, users should still be able to use the editors or tools of their choice. Picasso should primarily be a communication tool and, ideally, it should be accessible from within any application. It should not offer tools not relevant for or related to communication. Within the Macintosh platform this would mean making Picasso a desk accessory. This concept of a desk accessory—a major shift from the original stand-alone concept—was accepted, although in practice Picasso 2.0 was not implemented this way. It was implemented as a stand-alone application that offers the means to launch any other application.

#### ■ 4.3.2.2 *System primitives*

In general we saw a large gap between the users' communication intentions and needs and the functions available in Picasso 1.0. This is a central problem in user-interface design for which there are no clear solutions. For example, our design explorations proposed the kinds of system primitives needed for communications and computing that would allow users to construct their own locally relevant sets of functionalities flexibly. But we later realized that the system rather than the user should enact the scripts of primitives required to carry out work tasks and communication tasks. Otherwise, the learning threshold would be too high. In Picasso 2.0, we distinguished between functions directly aimed at communicating, those prior to communication, and those after communication.

#### ■ 4.3.2.3 *Projects and basic information unit*

By building Picasso 1.0 around projects, we forced people to organize their work artificially around projects. This was unfortunate, if only because the notion of a project in Picasso is an inadequate representation of a project in a real work setting.

In redesigning Picasso, we started focusing on system primitives like creating, editing, sending, deleting, and receiving documents. We found that Picasso should primarily support communication primitives, leaving all other document manipulations to Macintosh tools and applications. The focus on communication eventually led to the metaphor of a mailing label. In principle, the user only needs to specify Who (to communicate with), How (to communicate), and What (to communicate, if the action involves an object, such as a file to be sent). The user need not be concerned about file formats, communication protocols, modem settings, or baud rates, since we managed to automate almost all system actions from the information on the mailing label.

We focused on the file as a distinct unit of information, since all system operations (copy, move, edit, transfer, network, etc.) are defined at the file level. Some of the problems users had with Picasso 1.0 stemmed from our attempt to hide the file level. A Picasso 1.0 user can scan directly onto a card or create a full-page scan. In the first case a file has to be created before the scanned image can be sent; in the second case a file is automatically created to hold the scanned image which is later used to send it.

The text editing and drawing tools are also card based, thus any sketch that needs to be sent has to be turned into a file first. By acknowledging the file level as the basic information unit, we avoided problems of where things are stored and made a communication activity a uniform two stage operation: first create (prepare) a file, then send it off. We could have chosen to use arbitrary chunks of text or graphics as units, especially in combination with a true Picasso desk accessory. In this case, a user would select a piece of information (text, graphics, or of any mixed type), open the Picasso desk accessory, select a name, and the piece of information would be sent over to that person in the appropriate format. It would be possible to use the Clipboard as a buffer for copy and paste operations. This process would, however, require making (dummy) files out of these chunks before any machine-to-machine communication could take place. In addition, no commercially available piece of software supported these operations. Implementing it ourselves would have been a substantial effort.

#### ■ 4.3.2.4 *File transfer*

Although users could create text and graphics in Picasso 1.0 and send and receive them, the receiver could not edit them since they were sent as bitmaps, in a fax format. The advantage of sending files over faxes is the preservation of the original file properties (such as format). It offers a primitive form of sharing, although the sharing is asynchronous. A typical sharing interaction based upon file transfer involves sending version one of a file, receiving version two, editing version two, sending version three, and so on. We observed this at GG, and suspect it is a typical interaction in many groups where group members collaboratively work on one or more project deliverables.

#### ■ 4.3.2.5 *Mail scheduling and notification*

In Picasso 1.0 the manual scheduling of (fax) mail was a significant hurdle for the participants. For example, in order to send a fax, they had to scan a paper document and then complete a fax scheduling step. From the analysis of our data, we found that in this process the participants did not use the available phone directory, instead they typed the recipient's name and complete phone number every time they wanted to send something. (This is a typical example of what we call the "crystallization" of patterns of use. See section 5.1.2.3.) The phone directory, not an integral part of Picasso, was supported by the InterFax program where the scheduling took place. For Picasso 2.0, we decided to

automate the scheduling process as much as possible. We incorporated a phone directory which hides phone numbers during actual communication, and requires only the selection of a name and a file (fax). The use of one central phone directory had another advantage. Without it, the two communication programs in Picasso 2.0 would require two directories or two local copies of the directory.

In Picasso 1.0 the new and old fax mail being received could only be checked outside of Picasso via the Interfax program by checking the items Unopened Mail and Opened Mail respectively under the In Box menu. In Picasso 2.0 we created one central place to look for mail. Any type of mail is collected in one place and can be manipulated with the same set of operations: open, file (i.e., save), and remove (i.e., delete) a mail document. The user can ignore formats as long as the application is available. (Tools to open any type of document were not required for the sites we studied, since the same set of applications were used at both ends of communications. Incorporating such a tool would be necessary if the network of people is less homogeneous. See section 6.2.1.9.) The uniform Check Mail function shows all faxes and files, old and new, being received in one list. The mail notification is medium independent, which is important for multimedia devices.

#### ■ 4.3.2.6 *Screen sharing*

The Picasso 1.0 users showed an evident need for a screen-sharing capability. They engaged, for instance, in elaborate descriptions of modifications made to a drawing. They also expended a great deal of effort to coordinate their screen states for collaborative troubleshooting. In these situations, they had to rely on the audio channel to augment and coordinate other the communication channels. By adding a screen sharing facility to the system in Picasso 2.0, the communicative effort needed to establish coreference was drastically reduced.

#### ■ 4.3.2.7 *Simple scanning*

The scan procedure offered in Picasso 1.0 was based on the HyperScan tool. The distinction between card-sized and page-sized images presented a serious problem. If users scan directly onto a card, they have to create a file before the scanned image can be sent. However, if they scan a page-sized image, a file is automatically created to hold the scanned image. This is later used to send it. In general the scanning tool offered too much functionality for the most straightforward need—scanning a paper document. For Picasso 2.0, we decided

to offer the primitive scanning facility of InterFax. It offers a mini-preview function and controls for the image size, resolution, brightness and contrast. It lacks, however, a full-page preview function, zoom facilities, and other image-quality or special effects controls. Of course, as a result of the open system architecture, users can always use scanning tools such as AppleScan, HyperScan, or OmniPage that support a plain picture (PICT), MacPaint (PNTG), or Tagged Image (TIFF), file format.

#### ■ 4.3.2.8 *Application identification*

Picasso 1.0 consists of two HyperCard stacks, Workbench and HyperScan, and each project creates an additional stack. It took some time before our subjects knew what "the application" was. Picasso 2.0, developed in SuperCard, allowed us to create a stand-alone version, with a distinct application icon. (The other two reasons to switch to SuperCard were the ability to create windows of different sizes and the means to have multiple windows open at the same time. The latest release of HyperCard, version 2.0, also has these capabilities, but it was not available at the time.)

#### ■ 4.3.2.9 *Macintosh conventions*

By using an existing open-system architecture, the Macintosh, we inherited the basic set of metaphors and conventions of that platform. We used the standard file selection dialogs and conventions for buttons (e.g., use of ellipses if the action is complex), and we did not customize any of them. We observed, however, that understanding basic Macintosh conventions—the notion of files in folders, the file hierarchy, navigation through the standard file selection dialog box, switching from Finder to MultiFinder, double- versus single-clicking, and so forth—could be quite difficult for new users. A multimedia communication device should be designed with an open architecture, such that it has access to other tools on the same platform. (See section 6.2.10.)

### **4.3.3**

#### **Picasso 2.0**

Picasso 2.0 design presents a clean and deceptively simple interface in response to the difficult design challenges we faced at the outset of the project.

Picasso 2.0 is a tool for communicating with people through Macintoshes and fax machines. It allows users to:

- prepare files
- make changes in the phone list
- send and receive faxes
- send and receive mail
- send and receive Macintosh files
- chat (send typed messages in real time)
- share screens (look at somebody else's screen)
- control screens remotely (control somebody else's Macintosh)

The design reflects the process of communication. First people intend to communicate with someone; second they consider the means available for that communication, third they consider what to communicate. At the top level, we distinguished just three main functions:

- establishing a communication
- preparing files for communication
- checking incoming mail

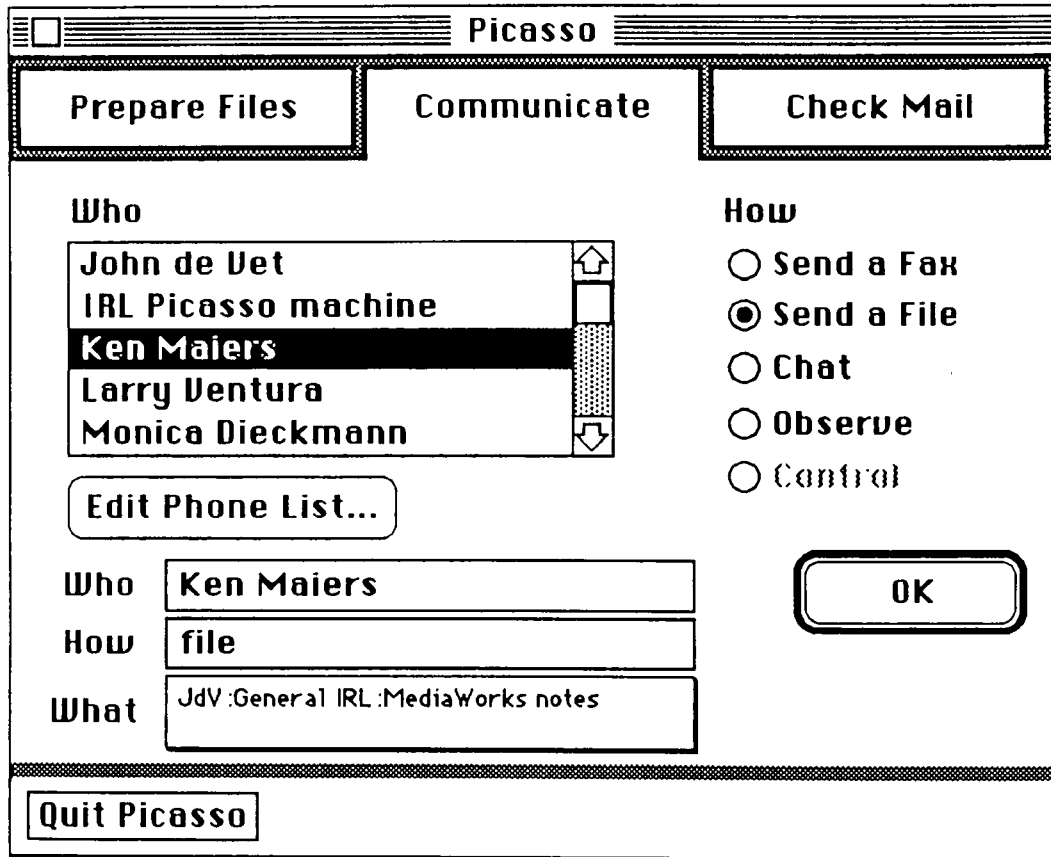


Figure 3: Picasso 2.0 main interface

The metaphor for communicating with somebody is that of a mailing label. It is broken down into a Who, a How, and potentially a What field.

Who: The selected name is displayed in the Who field. Picasso 2.0 maintains its own phone list. The user can add new, change existing, and remove old entries from that list (via Edit Phone List). Each entry consists of a name, a phone number (of that person's fax or modem), and information on available ways to communicate with that "name." On the top level however, only names are shown, the other information is hidden from the user.

How: The user then selects the type of communication from those available by clicking a labeled radio button under How. The How table,

a list of labeled radio buttons, shows what types of communication are possible with the selected person. The selected type of communication is displayed in the How field. Options that are not available for the selected person are disabled. For example, if the person only has a fax machine then only the Send a Fax option is enabled.

What: If the action involves an object, such as a file to be sent, the user is prompted to select that file, otherwise the What field will be hidden.

If the mailing label is complete, the communication action is fully specified and can be executed. All the required system actions—such as file format conversions, scheduling, and establishing a connection—are automated from the information on the mailing label. Fax and file actions are then performed automatically without further intervention from the user. These two establish a so called "dead-link" for the duration of the transfer. The other communication actions establish so called "live-links," which have to be ended explicitly by one of the participants.

#### ■ 4.3.3.2 *Preparing files for communication*

The file is the basic unit of information in the Picasso system, since all system operations (copy, move, edit, transfer, network ) are defined at the file level. All send and receive actions originate from files. Users can send and receive files of any type—text, graphics, audio (sound), animation, and video. The Prepare Files function supports a variety of ways to create (scan, new, copy, rename), and modify (edit, convert) files in preparation for the intended communication. While we were unable to achieve the ideal of making Picasso 2.0 a desk accessory, the Prepare Files function, which gives access to other applications from within a stand-alone application, presented us with a reasonable substitute.



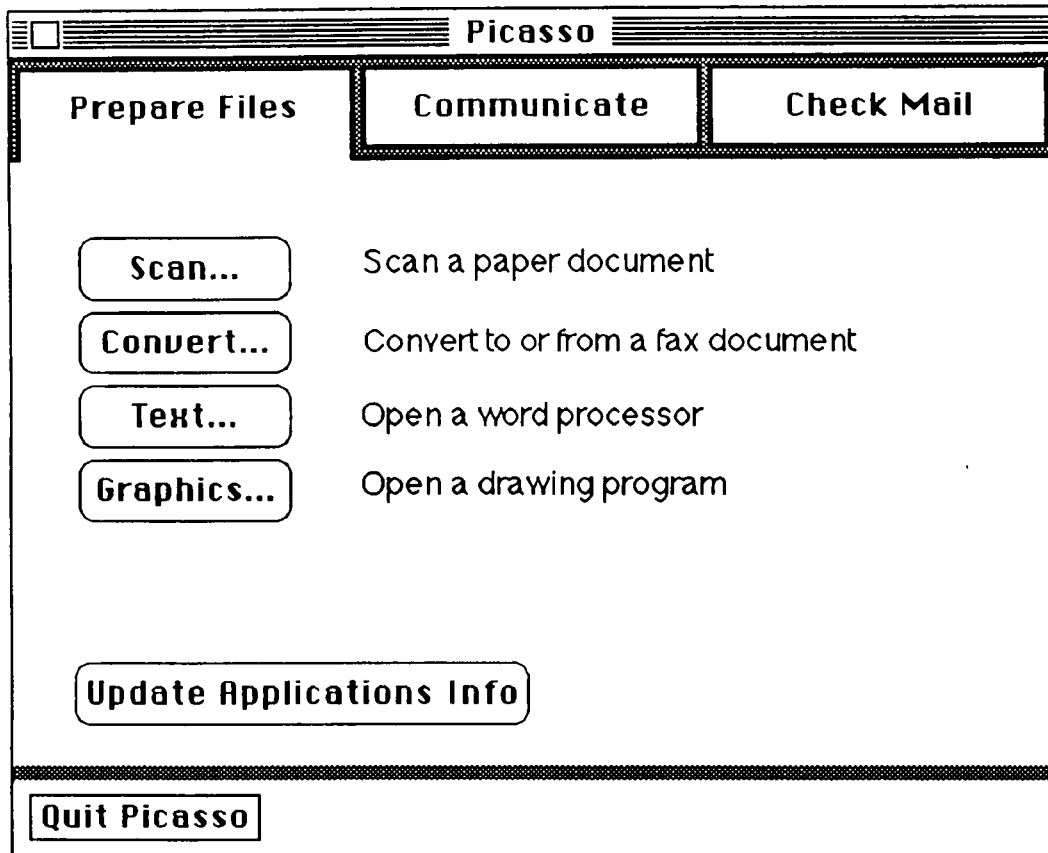


Figure 4: Picasso 2.0 Prepare Files screen

Paper documents can be scanned in (Scan...) and stored as fax (format) documents. If the user wants to incorporate scanned images into other graphics or text documents, fax documents can be converted (Convert...) to and from other graphic format files as a PICT, PTNG, or TIFF file. PICT format files are also available from drawing programs such as MacDraw and SuperPaint, PNTG format files from applications such as SuperPaint and FullPaint. Many different applications, particularly scanning programs, now produce some form of TIFF file. Usually most of the format conversion is done automatically from any type of text or graphics document.

The Prepare Files window also allows users access to the text (Text...), paint, or drawing program (Graphics...) of their choice. In order to open applications available on the machine, Picasso 2.0 scans the disk(s) for information on the

current applications (Update Applications Info). After quitting the selected application, the user automatically returns to Picasso.

#### ■ 4.3.3.3 Checking incoming mail

The Check Mail function allows the user to see what fax documents or files have been received from other Picasso machines or from fax machines. This provides a uniform way to check what has come in. Both old (or opened) and new (unopened) mail are shown in the same mail list, new mail preceded by a minus ("-") sign, old mail by a cross ("x"). For each mail document, the date sent, its name, and the name of the sender (if known) are shown:

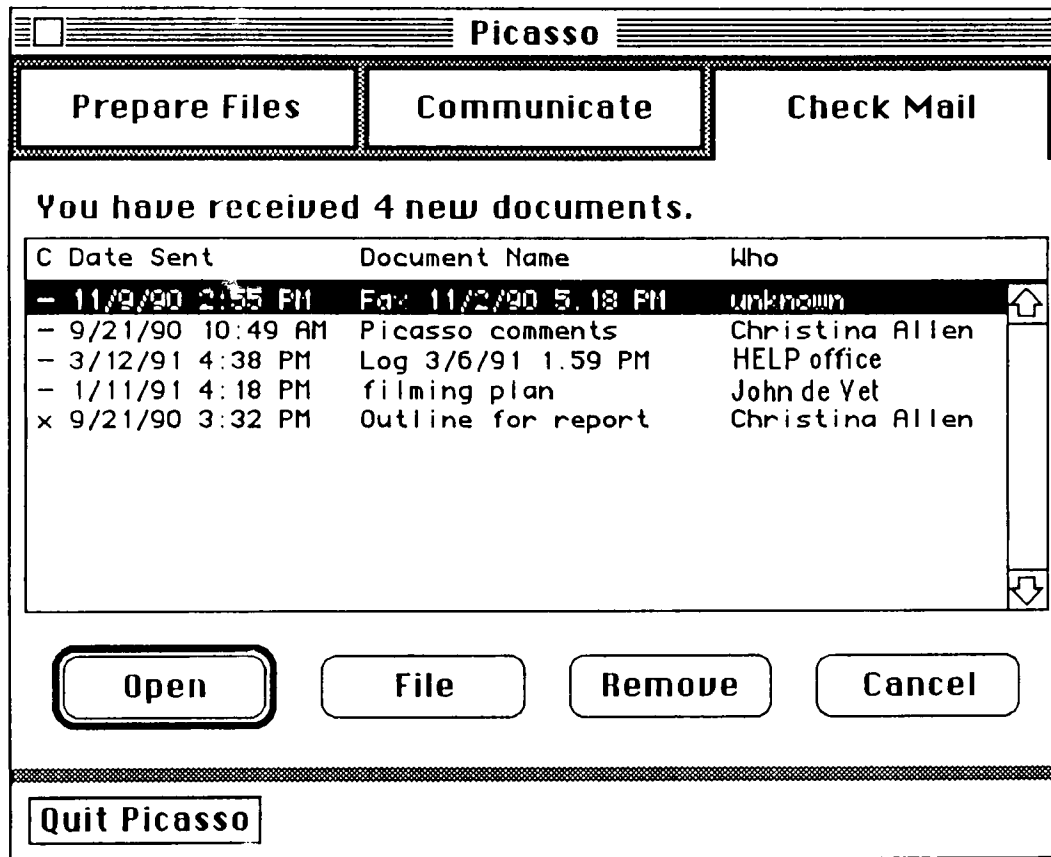


Figure 5: Picasso 2.0 Check Mail screen

Any mail document can be opened by a simple selection (select and Open). Again, the user can ignore format, as long as the application to open the

document is available. The user can save the mail document in any folder (File) or delete it (Remove). In both cases it is removed from the mail list.

There is no notification that new mail has arrived, but every idle second the mail list is automatically checked. The Check Mail button will be grey (disabled) if the mail list is empty. Clicking Check Mail updates the mail list. (This is a user-controlled action in order not to disrupt the ongoing operations on mail documents.)

#### **4.3.4**

##### **Picasso 2.0: Description and requirements**

From a technical point of view, Picasso 2.0 is an application on the Apple Macintosh built on top of four commercial applications:

SuperCard: Silicon Beach Software's SuperCard is a multimedia hypertext/prototyping tool, implementing the user interface (Himes & Ragland, 1990; Silicon Beach, 1989).

Interfax: Abaton's InterFax is a fax communication tool, implementing the (automatic) scanning conversion to and from fax documents and the fax transfers (Abaton, 1989).

Timbuktu/Remote: Farallon Computing's Timbuktu/Remote is a tool for Macintosh-to-Macintosh communication over a dial-up telephone line, implementing the file transfer, Chat (typed message exchange), screen sharing (observe), and remote control features (Farallon Computing, 1990).

Tempo II: Affinity Microsystems' Tempo II is a macro tool for automating Macintosh actions—the glue that links SuperCard to InterFax and Timbuktu/Remote functions (Affinity, 1989).

A complete Picasso 2.0 machine consists of an Apple Macintosh equipped with keyboard, mouse, hard disk, 4MB of RAM, System 6.0.4 (or higher), plus the Apple Scanner, Abaton's InterFax modem, Farallon Computing's Remote V.32 modem, LaCie's Phone Line Manager+, and a serial port switch box.

The memory requirements for Picasso 2.0 vary according to the functions being used. Using a 1024K System File, and 160K Finder, we installed Tempo II, which requires 260K (=224K init, 18K Tempo+ menu, 18K macro file), the InterFax Control Panel (80K), and Timbuktu/Remote, which requires 122K or 138K (=70+30+22K for SE screen, 70+30+38K for Mac II screen). Opening Picasso requires (+800K) 1984K. Opening the Control Panel requires (+33K) 2017K.

Opening the Chooser requires (+37K) 2021K. Opening Timbuku/Remote to chat or send a file requires (+90K) 2074K. Opening Timbuku/Remote to observe or control requires (+235K) 2219K. (On closing Timbuku/Remote some 25-30K "remain occupied.") Scanning or scheduling a fax document, which opens the InterFax application, requires (+384K) 2368K. Opening another 1024K application requires (+1024K) 3008K. While scheduling a fax from file, created by a 1024K application, requires (+1024+37K) 3045K. Other applications open under MultiFinder add the memory requirements claimed by those applications.

During our film sessions we collected screen data with Aura Systems' ScuzzyGraph, a color display controller for the Macintosh SE or Classic, which we used to obtain an NTSC video output. It connects to the SCSI bus and therefore could (but should not) interfere with other SCSI devices, like the scanner. It also affects the performance because of the QuickDraw graphics commands passed on over the SCSI bus.

#### **4.3.5**

##### **Limits of the prototype**

The Picasso Project sought to understand the design, introduction, and use of IMC devices. The actual prototypes are thus research tools that embody what we then knew about how better to support communication and learning through design. The prototypes were implemented with minimal cost and effort using off-the-shelf hardware (Macintosh, scanners, modems, phone line managers), a rapid prototyping environment (based on SuperCard and Tempo II), and communication software (Timbuku/Remote and InterFax).

A major problem that we faced is that the complexity of the prototype reaches the functional limits of its rapid prototyping environment. These limits are apparent in the design compromises (these are further discussed in the context of our design for Picasso 3.0, see section 6.2.2).

Ideally, Picasso should be accessible from within any application. Within the Macintosh platform this would require, as we noted above, making Picasso a desk accessory. Although we could offer a way out of Picasso, by launching any application, the way back to Picasso, by quitting the other application, is less obvious. The desk accessory approach would also have allowed us to use arbitrary chunks of information, instead of files, as the units of information.

Performance, especially response times for user interaction and feedback, is still acceptable, but should not degrade any further. The use of 9600 baud modem technology with ordinary telephone lines can be extremely cumbersome during screen sharing, where complex screen updates can take up to a minute. Furthermore, a SuperCard application is run by an interpreter, which delays some of the button responses.

The use of commercially available communication software in combination with a macro-tool resulted in a nonuniform and rather hybrid user interface. The dialog structure and appearance of interactive elements like windows and buttons of the underlying software cannot be changed or hidden from the user. In addition, keyboard and mouse input interfere with macro playback and cannot be blocked out. This led to unintended pausing of macros. (These can be easily restarted if the user recognizes that it was a macro playback.)

Since both the fax communication software and the Macintosh communication software need a modem to operate and each modem requires a serial port, a complete Picasso workstation claims both the printer and the modem port. This meant that we could not attach a printer or an AppleTalk network unless we shared one of the ports. In Picasso 2.0 we installed a serial port switch box to share the printer port with the fax modem and the printer or network. As we expected less fax communication than Macintosh-to-Macintosh communication, we chose the fax modem. Because switching has to be synchronized by some software settings, we provided some coordinating macros. Unfortunately, we saw some instances of incorrect settings where switch box and software didn't coordinate and as a result either pages could not be printed or faxes could not be sent. Clearly we would like to operate multiple modems in addition to existing peripherals.

Picasso 2.0 draws the user's attention to new mail only when it is the active application. There should be an integrated mail broadcast function which signals any incoming mail independent of the application the user is in. This requires a multitasking environment, or at least an environment where the active application can be interrupted.

File transfer, like fax communication, should be handled as a separate, background task, freeing the resources for other tasks. Too often both senders and receivers are blocked because the communication program claims all computer resources. Again, this requires an operating system that supports multitasking.

Adding additional functionality to resolve any of these issues would require a considerable integration effort. It would involve a complete or partial reimplementation (in, say, C) of the required functionality in combination with and depending on access to the source code of the underlying software or access to (traps of) some appropriate subroutine calls. But for the purposes of the project, we decided not to invest in serious development and to accept the ensuing side effects. As a consequence of this decision, we were always aware of the danger that, in a prototype of this complexity, our compromises could render the technology less transparent than it might otherwise have been.

## FIVE: RESEARCH TOPICS

In section 2.5.5 we noted that we identified five major research topics as a result of the Picasso project:

- collective learning
- communication channel use
- social negotiation of attitude toward technology use
- meeting and agenda management
- ongoing activity and the structure of turntaking

Section 5 of the report discusses these in detail.

### 5.1: Collective learning

We were particularly concerned with why, how, and what learning occurs in situations such as those we studied.<sup>5</sup> For a technology-centered community, learning is usually seen as individual "bootstrapping." We found, however, that viewing learning as a collective process provided a new understanding of what learning is and how it can be achieved.

In this section we look first at some

- general findings gained from this perspective on learning.

Then we distinguish two levels of learning in the workplace:

- learning at the use level—how people collectively learn to use the functionalities of a new technology in relation to the tasks they will use it to perform
- learning at the organizational level—how this learning and use of tools in organizational tasks effects change, particularly social change, in the organizations in which they are used

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<sup>5</sup> Issues discussed in this section are developed in Allen & Pea, forthcoming (Picasso Publication 3).

Conventional studies of learning usually make three distinctions, separating learning at the use level into learning tool functionality and learning to use the tool for particular tasks. Because in our studies the participants were inevitably learning the tool in the context of their actual work tasks we found it practically impossible and analytically unhelpful to maintain this distinction.

### **5.1.1**

#### **General findings**

Here we found two important characteristics of the learning situation:

- complexity of the learning environment
- collective learning infrastructure

#### ■ 5.1.1.1 *Complexity of the learning environment*

In general, we found that the environment in which most learning takes place is extremely complex. Workers learn in the middle of other tasks, ongoing responsibilities, multiple conversations, and interactions with coworkers, who move in and out of the learning process. Moreover, most workplace learning takes place when a task needs to be completed. Thus by its very nature, it is learning in doing. As a result, learners take advantage of the resources most readily available in the flow of activity and most salient at that time—whether or not these resources are, from the more abstract point of view of designers, "optimal" or "complete." It could be argued that this finding is an artifact of our experiment design: we introduced the new technology into the workplace without setting up separate training sessions. In fact, this choice of design was deliberate. Most new office technology is learned in the course of ongoing work, rather than at off-site or after-hours training sessions, and so our understanding of learning must cover exactly this situation.

Occasions when participants encountered an impasse provided important opportunities for us to observe collective learning and to identify our participants' resources for getting on with their work in the face of trouble. These resources are distributed throughout the complex workplace. At the level of use, manuals and on-line help can provide some help. In general, however, resources for learning and decision-making are distributed in the practices and the social and organizational fabric of the workplace. Asking someone for help, asking them how they did something—in fact, the very process of coming to learn who to ask,



who has experience that can be exploited for one's own learning—is a crucial aspect of collective, situated workplace learning.

For both levels of learning, the complexity of the learning environment and the complexity of the distribution of the truly useful learning resources are relevant.

■ 5.1.1.2 *Collective learning infrastructure*

The phrase "collective learning infrastructure" refers to the diverse resources available in the tool, the material, and the social environment to support (or constrain) learning among coworkers. These three—the infrastructure made available by the tool itself, the material aspects (e.g., adjacency) of the layout of coworkers' offices, and the extent of the support provided by the organization for distributed expertise and changing patterns of work among coworkers—all contribute in a substantive way to the collective learning.

Coworkers who are physically separated but must learn and work together face particular infrastructure problems. They have, for instance, to do a good deal of communicative work to establish common reference ("coreference") to objects and documents and to create and maintain conventions for the use communication channels.

The problem of establishing coreference is particularly apparent in phone sessions before the introduction of Picasso. In the examples below, The graphic designers M and N are looking a series of proposed designs. Because they do not have physical or technical resources for pointing, they must use complex verbal descriptions to establish reference to the particular design they wish to focus on.

00:04:10<sup>6</sup>

N: If you look at uh the third line down, the one on the left, that has "training for business" under it.

---

<sup>6</sup> Speaker turns of particular interest are underlined. Emphases made by the speakers themselves are represented with bold type. For a full list of the protocol conventions see appendix 2.

00:04:46

M: Well, I don't like some of them. I don't like the ones like on the top where she has just the little pieces sticking out.

00:04:53

N: I don't think she likes any of them, the one second from the one on the right on the top row looks like a cannister or//

M: //or tombstone, when I first saw it.

These sorts of problems of establishing coreference are intrinsic to work done by telephone and are not addressed at all by Picasso 1.0. For this reason, we implemented screen-sharing functionality in Picasso 2.0. It was then possible for coworkers to establish a shared screen which could either be controlled or observed remotely. The noticeable improvements in the capacity of Picasso 2.0 to support collective learning is evident in protocols such as the one below. The participants treat the jointly visible screen display across the miles as if it were an object in front of them in real physical adjacency, as "virtual presence." They use the mouse cursor as a pointing object and pronoun phrases such as "close that up," instead of lengthy definite descriptions.

00:37:34

M: Okay, let's see, I put it to 70 percent, well, you saw that, I don't have to tell you. Awright. And, I'm going to move over here, to the umm, move over to "The Solution" side.[Pause] Awright. Now what I'm suggesting is [Pause] um [Pause] me [Pause] whoops!

N: Y'know, I can't remember how many text boxes I made there. You might wanna click on 'em and see where the text boxes are.

M: Close that up [Pause] and close that up. And if anything, umm [Pause] is this all in one text box? If anything, maybe create more space [Pause] here.

After working in this way, the participants evaluate the ability to establish coreference easily as one advantage of the new technology.

00:43:34

M: Well that's great, that's nice, so I controlled your screen.

N: Hahaha [Pause] power, power.

M: That's kind of fun.

N: At last.

M: Well that makes it real clear, you know, talking about tops and bottoms and sizes. Boy that was a real puzzle.

—referring to their past practice of trying to coordinate screen states over the phone when looking at their computer screens in Picasso 1.0 without screen-sharing functionalities

Now let us move on to look at more specific findings about learning in the workplace at the two levels we have distinguished.

### 5.1.2

#### **Learning at the use level**

Learning at the use level involves both coming to understand the functionalities of the tool and coming to understand the relation of these functionalities to the tasks of ongoing work. As we noted above, in the learning we observed, these two aspects of learning are inseparable. From our observation of learning with Picasso, however, we did identify four central, separable issues in the collective learning of tools at the use level:

- collective learning and embedded structure
- differing learning strategies
- crystallization of pattern of use
- user-defined functionality

#### ■ 5.1.2.1 *Collective learning and embedded structure*

We observed that in learning at the use level, individual tasks were often nested within larger structures. One worker may have the desire to do task A, which requires learning how to achieve subtasks A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>. Learning how to achieve a subtask A<sub>2</sub> may require learning how to achieve sub-subtask A<sub>2.1</sub>, and so on. One of the more striking and positive aspects of such embedded learning is that,

when it is successful, it is likely to be remembered, because the subtasks are learned and come to be achieved in the situational context of a larger, goal-directed effort rather than as an arbitrary learning task.

The most important problem we have identified in such embedded learning structures is goal entropy: The coworkers may pursue a learning path of subgoals and never return to complete the original goal that sent them on their learning agenda path.

#### ■ 5.1.2.2 Differing learning strategies

Some workers prefer using a manual, others testing and experimenting with the tool. In collective learning, the choice of strategies is often in need of negotiation: proposals for how the process of learning together will take place are constantly enacted or mentioned, including such aspects of learning as whether to go on learning right now, how to learn more in the future, what to try next this moment, and why to try to learn this tool at all.

The following examples provide evidence for this phenomenon.

In the first example, M and N prepare to learn how to control one another's computer screens remotely. Each draws upon a manual at some point, and both try to coordinate where in the manual to look for help. They then negotiate who will do what in this learning session. N says "I wanna leave my screen alone" and suggests that M "select the control option from the Picasso mailing label box." M and N then spend several turns clarifying their collective learning goal, and that M will be playing the lead role in learning to control N's screen. Once M succeeds in this, with various supportive remarks along the way from N, she makes note of their collective achievement in her pronoun use in "all right now let's see, we're done here" (not included below).

In the first part of this example, M and N agree to try to learn remote screen control.

00:27:16

N: Well, you see, what we ought to be able to do now, is that you ought to be able to change it and then it would change on my screen.

M: Ehm, I can c . . . [M is flipping through the manual]

N: Well, there's a way to do this, so that  
[Pause]

M: I I I [Pause]

N: Isn't there? Isn't there someway we can do  
this, I mean. [Pause]

N picks up the manual now.

M: I think you can watch me change mine.

N: No, but you can take control of my screen.

M: Yes, I can control yours, but ehmm . . .  
but I can't by controlling mine, control  
yours.

N: Do you have to go back to Picasso somehow  
and get my screen up on your [Pause]

00:27:58

M: Well, [reading aloud from the manual]  
"controlling the screen of another."

N: You have to get my screen up on your  
computer, and then you can change it, and  
then you could put yours up and I could  
control yours. [pause] What page?

M: Thirty three. [pause] [reading] To control  
someone else's screen, we have to select a  
who and then select control under how. So,  
I guess we have to go back?

They then negotiate roles in the lesdarning procedure.

N: I guess [Pause] Ok [Pause] [clears throat]  
Excuse me. Ok, so I think I wanna leave my  
screen alone, and you should [Pause] I  
guess you wanna select the control option  
from the Picasso mailing label (XXX) box.

M: Wait, I'm going to [Pause] ah, er, ah  
[Pause] Umm, awright, I'm going to quit the  
application.

00:29:34

M uses "Quit the Application" from the Mystery Menu to quit PageMaker which is still the  
active application. This brings her automatically back to Picasso

00.29:40

N: I guess you can't have two things open at once, huh?

M: Umm, I don't know. I'm gonna do it from scratch, and then we can see [Pause] so I'm going to control your screen, right?

N: Huh?

M: Is that what we're trying to set up now? I'm going to control your screen.

N: Yeah, I'm not doing anything. I'm waiting for you to show me how you would like to space that stuff.

In the second example below, from the HELP site, L and K are working together to learn how to Chat with Picasso 2.0. L proposes that they each individually read the manual and then call each other back. But this proposal is not implemented; instead they pursue the learning in real-time. However their learning goals are not at all met well by the structure of a manual. K looks in the manual to try to find an error message symbol that has appeared on her screen, while L experiments with the tool without reading the directions. K and L then agree to figure out how to Chat. They interweave reading parts of the manual aloud over the phone, with somewhat self-oriented thinking aloud and with attempts to coordinate their screen states. They end with a successful Chat session and obvious satisfaction in their achievement.

00:36:40

L: Do you wanna just read the directions and then play with it and then I'll call you back, or . . . .?

K: Yeah I'm gonna try to find out what this little symbol means. It's kind of an exclamation point, sort of . . . .

K refers to the exclamation point in the error message window. She is looking in the manual for that picture.

00:36:59

L: I'm gonna press, I'm gonna see if I can, uh, I'm just trying something and I haven't read the directions.

K: I want to do the Chat thing.

L: I'm doing that too, it just looks

00:37:15

L okays the "Chat with K" action, reads the text in the "Confirm" window, and—after a short hesitation—confirms that action.

L: [to herself] Ok, "Chat with [Pause] by typing text in the Chat window, it will appear after you hit 'ok.' There will be a lot of" [Pause] [to K now] OK, I'm gonna type text in the Chat window. [to herself] All right, where's the Chat window? It will appear after I've hit "ok." (XXX) All right, we're in Chat. OK.

00:37:45

L: Did you press Chat?

K: No. That's under Communicate?

L: Um, I don't what it's under, but they're dialing you. [laughs, pause] It says dialing access is off.[L's modem is dialing] Um, you know on your machine you've got a thing that says, uh, "Set to Fax, Set to Print?"

K: Yeah.

L: Is it it set to fax?

K: Yeah.

L: Okay.

00:38:18

K: I'm receiving something.

L: Yeah, my machine is calling yours.

K: I'm answering your call.

L: I think we better read on, read about Chatting [picks up manual].

00:38:43

Chat window comes up on L's screen. One second later, after a beep, it comes up on K's screen.

00:38:47

L: Ok, now [Pause]

K: I have connected too

L: OK, it looks like if we typed in the box, we could maybe, let's see, maybe we could see what one another's typing. I'll put something in the box [reads the contents of the menu, sotto voce].

00:39:18

L types text in the Chat window, but she doesn't hit the return key (so the message is not sent).

L: Are you getting anything on your screen?

K: No, I have been connected to you and then

L starts reading the manual.

00:39:52

L: I'm reading the directions on Chatting, and trying to find where they are.

L tells K what pages in the manual she is reading.

K: Four point three point three is "Chatting with Another."

L: OK, thanks. What page is that?

K: I dunno. Um [Pause] twenty-seven [Pause] twenty-eight.

00:40:17

L: All right, ok, we've got, um [Pause] I don't understand why I can't send you that fax. That annoys me. [reading from manual] Ok, "Chatting with Another," all right [Pause] all right [Pause] ok [Pause] ok [Pause]

00:41:15

They confirm that they both have the same screens. K is looking back and forth between manual and screen.



K: Ok, you see the screen on page twenty eight? I mean, twenty nine?

L: Yes.

K: With the "attention/control/observe" (XXX)?

L: Yes, yes.

K: That's the screen I have.

L: That's the screen I have, too.

K: Ok, and at the top, "connected to," it says "[L]"?

L: Right.

K: Does yours say me?

L: Yeah.

K: OK.

00:41:33

L: I typed in a message on that, and I don't know what to do from there. [pause] I've typed in my message in the lower window. [reads again] "clicking the mouse in the lower window and starting to type" [Pause] Oh, I press the return key! All right [Pause] oh.

00:41:56

L finally presses the return key and thus sends: "Hi—How are you?" K receives the message on her screen and laughs.

00:42:08

K: How do I do it. Just type?

L: Uh, yeah. You gotta be in the lower window?

K: I am.

L: All right.

K types a response.

L: Hahaha!

00:42:38

K: Do you have to send it?

L: Yeah press return. Just press the return key.

00:42:40

K hits return and thus sends (i.e. Chats) "super!!! lets have lunch." L reads it and laughs.

#### ■ 5.1.2.3 *Crystallization of patterns of use*

Workers often learn patterns of use of the technology that the designers would not consider optimal, but that the learners consider to be successful. Such patterns of use can constitute plateaus with respect to the learning of prescribed tool functionality, but as we have noted, these patterns can be important adaptations of tool to task at the use level. We describe this phenomenon as "crystallization" of learning.

We find a striking example from the GG site in the way M and N use the scanning application component of Picasso. The software for scanning utilizes a direct manipulation metaphor of "stretching" the borders of a physical representation on the screen of the area to be scanned of a document that is placed on the platen of the actual scanner. By adjusting this rubber band-like border on the symbolic representation of the document, the user selects the area that will be scanned. But the GG users evolved a different way of using this function of the software. Instead of using the software "rubber band" to adjust the area to be scanned, they would continually realign their document on the actual scanner. While this practice has a likely precedent in their experience with a copying machine, it is "unproductive" in terms of the prescribed functions of the scanning software. But for their purposes, they were successful in how they used the scanner and software, achieving their goal of scanning a designated area of a document. Once their success was established, they did not seek any other way, to "optimize" the achievement of their scanning goals.

Other more complex examples occur as well. At GG, when first using Picasso 1.0, one of the workers achieved success in creating and faxing a file through a labyrinthine sequence of screen operations, far longer than the several keystroke sequence that was intended by the designers. This sequence came to be used by the other partner as well.

The general implications of examples like these are great: Since such learning takes place in a complex and interactive social arena, these patterns of use may

propagate to other users. Subcultures of use within an organization may be created that can look very different from one another, and from the prescribed functions of a software application. Without specific incentives to learn such prescribed functions, and with the success of other use patterns, the user communities will persist in their practices with the technologies (MacKay, 1990).

#### ■ 5.1.2.4 *User-defined functionality*

Learning a tool involves coming to understand how this technology might be of use to do the work at hand, and also, how the processes of the work at hand might change as a result of the difficulties or affordances of the technology. This kind of learning may overlap with prescribed functionality of the tool, but it often has considerably different boundaries. Here, as distinct from cases of crystallization, users discover and define uses for the tool—uses never envisioned by designers—and ignore uses that are part of its prescribed functionalities.

One of the most striking examples occurred at GG. The scanner hardware and software that is part of the Picasso system slightly degrades image quality, although this was not an intended feature of its design. However, when M and N observed this side-effect of the scanner, they found this degradation to be an exciting artistic effect. They would scan and print and scan repeatedly to give an image a fuzzy quality when they found this effect aesthetically appealing.

Another example comes from the HELP site. Among coworkers at HELP, the Chat functionality of Picasso 2.0 became popular as a joking and entertaining activity. This surprised the workers there. When they read about the functions provided by the Chat feature before the installation, they said that they could not imagine ever using it, since a phone accomplishes roughly the same kind of connection. Whether the Chat socializing and entertainment found in early sessions will persist, or is just a novelty, is unclear as yet. However, it is interesting that existing social relations and the possibility of extending them provided a motivation for interacting with Picasso for people who would otherwise have had no reason to try it.

We have found that users have expectations about what a tool should do based on their work experience, and that often learning is oriented toward discovering whether this expectation is a valid one. For example, this was apparent for Picasso 1.0 when the coworkers expected that they would be able to use all their existing applications within the Picasso environment. Their expectation was not

met by Picasso 1.0, but this failure served us as a useful guide for designing Picasso 2.0.

We have also found that as the learner's success with the tool for work increases, so do their desires for it. They are often quite articulate about what they would like the technology to be able to do in the next version. One worker at GG made repeated requests during the work sessions we observed with Picasso 1.0 for a kind of screen-sharing facility, complaining of the difficulty of establishing a common ground in communications. Yet she was unaware that such connection between remote sites was even technically possible. Happily, it was technically feasible to implement such a facility as part of Picasso 2.0.

### **5.1.3**

#### **Learning at the organizational level**

Learning at the organizational level concerns the effects of the technology on the roles, relationships, expertise and general work practices of the workplace. The introduction of new technologies into the workplace can be instrumental in changing the organizational and social relations of the people working there. In this context we noted three significant issues:

- social negotiation of attitude
- distributed expertise
- expertise differentials

##### ■ 5.1.3.1 *Social negotiation of attitude*

The ways that a community evaluates a new technology have a strong effect on learning. The community's attitude effects the general disposition of its members toward a new technology. How the technology is introduced, who introduces it, the process by which its appearance is decided, and who champions and supports it within the workplace over time has much to do with the attitudes that will be displayed among workers, and thus the role the technology will come to have in the workplace. We discuss this in more detail in section 5.3.

##### ■ 5.1.3.2 *Distributed expertise*

Not every worker at a site has to become an expert user of the resident technology. Rather, people develop an understanding of how knowledge about the

technology is distributed in the workplace. This includes who knows how to use it, who is available for help, and the political ramifications of asking this or that person for help. Unfortunately, the reality of the distribution of expertise rarely maps onto the institutional expectation of expertise. In our most salient case, H, a coworker at HELP became the site expert on the use of the Picasso technology rather than K, whose initial responsibility it was. Learning and using Picasso was in no way a part of H's formal job description. The fact that expertise will emerge in unpredicted places with no respect for established hierarchies requires the organization to have an ability to respond to continual changes in work abilities and relations.

#### ■ 5.1.3.3 *Expertise differentials*

When workers collectively learn how to use a new technology, there are inevitably asymmetries that emerge in expertise with particular tool functions. Since expertise varies, and effectiveness of a communication tool requires that there be rough equivalence of expertise on both sides of the tool's use, we saw the emergence of social pressures on people to achieve a higher facility with the tool's functions. These pressures from one side of a collective learning dyad are often met with apologies and plans for learning on the other side. In the case of GG, M early on made rapid strides in learning the functionalities of Picasso and pushed N to move to this level of expertise. This subject formed a common focus of Picasso conversations. Sometimes, however, pressure does not manage to bring the designated learner up to speed. In such a case, success may still be achieved if distributed expertise emerges elsewhere in the organization. For example, someone in the organization but outside the collective learning relationship might become facile in the use of the tool, thereby establishing the desired result of symmetry of tool expertise across worksites.

### **5.1.4**

#### **Design implications**

The conceptual shift to collective learning has significant implications for designing resources for learning. In the first place, traditional resources—documentation, animated examples, and other models—presuppose a solo user. But as we have seen, learning in the workplace is often achieved and defined collectively.

Furthermore, designers tend to think in terms of a simple dichotomy between naive and expert users. In fact, there is usually a very wide range of users. In our research sites, some users had never used a mouse, while others were facile with ten complex graphics programs. Each level of use required very different design and support facilities. Yet these may all be thought of as "naive" users since they are new to the particular technology. One design implication of this finding is that guided tours, manuals, or any other instructional materials need to be set up at a variety of levels of expertise, so that the learner can choose the appropriate level.

Overall, however, it is our view that there is no stable set of functionalities for tool use in a particular cowork practice that "training materials," or "help systems" can be designed to support. Instead, we see that the designer's learning-support goal is to create communication channels—both among users and between users and designers—so that there can be a continual reciprocal evolution of tool and work practices.

Rapid learning should begin this process; users should be scaffolded by the design of the new tool into the task space of their existing cowork. This collapses, as we have done, the distinction between learning the tool and learning the task as quickly as possible. When users buy some IMC device because they think it will be useful for specific work tasks, they must be able to appropriate the technology for those tasks rapidly. Early appropriation of tools for tasks by users will provide them with sufficient motivation and momentum for further exploration and learning. The value perceived by the user of any added functionality to an IMC device is founded on the success with which the device is appropriated for familiar tasks.

Beyond this, there is the further challenge of providing the users with space for discovering what happens when they try to coadapt the tool and their existing work practices, as well as how their work practices can expand when they use the new tool to generate new and unanticipated work practices. We see such platform functionalities as screen-sharing and an ISDN voice channel for "live link" commentary on other media of communication as critical for achieving the collective learning infrastructure which permits people to evolve patterns of cowork with new multimedia communication tools.

### 5.1.5

#### Research Implications

In summary, in our theoretical perspective for examining computer-supported cowork, we have emphasized collective learning rather than individual learning, and learning by doing, rather than learning for doing. A new look at learning is required, one that views learning in the context of social environments and real tasks as more fundamental and natural than the separation of learning from doing—the prevalent approach found in schools, industrial training, and manuals for introducing tools. Learning in the context of use avoids the problem of transfer. When learning takes place in the achievement of authentic tasks, there is no need for concern about whether learners will be able to transfer what they have learned from the situation of learning to the situation of use. Learning in use also includes learning the usefulness of tools as defined by a community of tool users. For increasingly complex and tailorable systems, uses of documentation as a way of learning tool use will become less credible. Social sharing of effective uses of tools will be more important.

Our research on the nature of learning in the workplace shows that expertise is distributed, that learning is task focused rather than tool focused, and finally that collective experiences of learning and using and talking about technology by coworkers has a lot to do with the developing ecology of use in the workplace, and the changing organization.

We have emphasized different aspects of learning from those traditionally considered in research into learning of new technologies. By looking at aspects of learning that are embedded in work practices, we were led to different implications for appropriate research for computer-supported cooperative work environments than we would have been by a primary or exclusive focus on tool learning. In particular, we focused on:

what is learned: not just features of a tool and procedures for using it, but also the fit between tool and cowork tasks determined by the user community

why it is learned: not just because of instructions to learn from a manual, but because of pressure from the existing user community to learn, in order to become capable of participating in cowork

how learning takes place: not only through the development of a mental model of how the tool works, but through the collective negotiation of tool usefulness within an organization (which is more a function of social

organization than of the intended functionality of the tool), and through the negotiation of the distribution of expertise in the uses of a technology among coworkers in an organization

## 5.2: Communication channel use

As a communications technology, Picasso expanded the number of communication channels available to coworkers and often necessitated a choice among channels.<sup>7</sup> The choice of a particular communication channel raises important technical and social issues. This section examines the ways in which participants developed uses and conventions for channels, and the effects this had on the organization of their work. We are particularly interested in

- channel negotiation—the negotiations that arise around the use and coordination of channels
- channel conventions—the designation of one channel to correct and augment the information that is sent over another
- shared space and "communication veils"—the organization and maintenance of shared and private spaces

### 5.2.1

#### Channel negotiation

In the course of using multichannel communication technology, users can often determine for themselves what channel should be used on a given occasion for a given task. As the discussion below indicates, discussions of this kind can aggregate to develop into a general convention.

First, we found discussions about what channels to use to organize a work session. In the following example, the users discuss whether it is appropriate to stay on the phone while trying to use the fax.

N: Where does it come?

M: Just to, probably [Pause]

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<sup>7</sup> Issues discussed in this section are developed in Allen & Linde, forthcoming-a (Picasso Publication 4)



N: Am I gonna get it on my screen?  
M: Ummmm, you'll get it as a fax, right?  
You'll have to open "new fax received" as soon as I send it.  
N: [Pause] When it's not there.  
M: Well, then, I'll send it. ok?  
N: Yeah.  
M: And we can start [  
N: [You wanna hang on the phone and see if it comes?  
M: Oh yeah, I think that's the idea is to talk and send to each other.  
N: Yeah.  
M: Fax and talk simultaneously, so that's [about  
N: [Uhn. Fine. OK. Yeah.  
M: Um, ok. So. "fax to be sent"

In the following example, the users negotiate how they will read the manual. They decide that they will stay on the phone while they do so.

L: Umm, we should look at that first and then do "Using Picasso." And then try, I'll try to send something to you.  
K: Ok. So am I just reading this and waiting?  
L: Uh, I guess so.  
K: OK. [laughs a little]  
L: [laughs] I guess I'll leave the speaker phone on?  
K: Are we just staying on the phone?  
L: Yeah, let's see how that goes a minute. Yeah, let's stay on the phone a minute.

We found that the telephone is the unmarked choice for organizing a work session, particularly during the period of learning Picasso. People use the channel they are most familiar with as the channel to organize their interactions with unfamiliar and therefore unreliable channels. (See section 6.2 for a discussion of the implications of this finding for determining the need for ISDN.)

We also observed negotiations about whether a given channel should be used for a particular task within a work session. These may include discussions of whether to use the fax, whether to initiate screen sharing or remote screen control for a task, and so forth. For example:

N: Should I scan you a copy of this logo?

M: Um, well, it looks like you've got, you've got most of the materials for the design of the cover. Ummmmm, yeah, I mean, yes, I guess so, yes. [very flustered tone of voice] I guess I'd like to have a, a copy of it uh, anyway.

Negotiations also turn on personal or work-centered issues, rather than merely technological issues: whether the potential recipient actually wants the potential task which the document to be sent represents. (This is a "ball is in your court" issue.) Such negotiation has to do with the technology only to the degree that the technology makes such a transmission possible.

Two distinctive issues in channel negotiations stood out from the data:

- representation quality—whether a channel will provide an adequate representation of the original
- channel augmentation—when participants use a second channel specifically to comment on or discuss a document, representation or system feature in another channel

#### ■ 5.2.1.1 *Representation quality*

Participants had on occasion to negotiate how to achieve adequate quality of representation for the communicative task at hand. At issue in the example below is whether it is possible to get an adequate representation by scanning and faxing a document from a client on thermofax paper.

N: So, listen. I wanna scan you a couple of things that um, I got from Hollister Health, and see if I can get 'em to you.

M: Alrighty.

N: If, They look weird. You know, these may not scan well. Uh. This does not look, it's hard for me to tell whether it's looking odd because it's uh, you know, the

reduced size. Whether this is \_\_\_\_\_,  
Whether this is, hm. What's the story,  
here? [lifts up the scanner cover] Well, I  
can but try. Um, I have a piece, I'm  
trying to scan something that came out of a  
thermofax-type sender

M: Ooh.

N: And, maybe it's not gonna work. In fact,  
well, we can, let's just, let's just see.  
If it does.

#### ■ 5.2.1.2 Channel augmentation

We observed that participants often used a supplementary channel to provide additional information for successful communication. In the example below, two channels are in use: fax and phone. The phone is being used to augment the information available in the fax, and in this case, to clear up some significant misconceptions that had arisen because of differences between the representation quality of the original document which was faxed to the sender by a client, and the photocopy of that document which she has mailed to her partner.

M: Well, I like, I like, um I like the one  
that you had circled, that Nancy likes, but  
only if [Pause]

N: But you see the "P" disappears and you  
don't know that that's an arch either

M: Well, you don't know that it's [Pause] you  
don't know that it's, well, look, I guess I  
had two reactions to it, you notice it's an  
arch I think only [Pause] because of the  
grey smudging that they did around it//  
that makes it look like a wall.

N: //[laughs] no, but that's, that's me.

M: Oh that's you! ahha.

N: Yeah, they didn't do that.

M: Oh, that's you.

N: [laughs] Yeah what that is that I drew  
some stuff around it and then when we were  
going to Xerox it I wanted you to see the  
original, so I erased it, //but because it

was on the crummy fax paper I couldn't get it off.

M: See I liked that. Well that's interesting cause I liked it I liked it with the smudging around it, it looked like it looked like you know an old cement stone wall of some sort.

Similar needs for augmentation may arise as part of the problem of establishing coreference: that is, determining that both partners are attending to the same document, version, feature, and so forth. In the following example, the two participants are using the screen-sharing functionality. They attempt to determine that their screens are the same and that they are looking at the same thing. It is clear that the telephone is essential here as an augmentation channel: they could not establish the coreference using only the screen sharing functionality.

N: Uhhh [Pause]

M: Now you're **way** up on screen.

N: Yeah, well, something funny happened. Can you see what I'm seeing?

M: Yep. Oh, well, I mean, I can see your hand, your little hand icon is [Pause]

N: Can you see that I'm trying very hard to click on this menu? Now "Communicate" came on, and I didn't click on it. You're not doing anything, are you?

M: No.

N: I'm trying, there are little arrows here. I'm trying to click on the little arrows to get this thing to move over.

## **5.2.2**

### **Channel conventions**

The Picasso system gave us the opportunity to see conventions for new communications channels being established. These conventions partly arose as the accumulation of a series of individual negotiations about what channel to use for a particular instance of a work task—negotiations of the sort we described in section 5.2.1. Conventions may also develop out of an explicit policy decision

about how to use the technology. Such discussions had to rely on some channel other than the one for which the convention is being established. In the following example, the participants begin to negotiate their conventions for leaving fax lines open so that they can send faxes at times other than scheduled meeting times.

- N: I might fax you some odds and ends of things over the weekend, and um, I don't, I'm just thinking, I guess we'll hear the phone ring if either one of us decides to fax the other one.
- M: Yep.
- N: Um, other than that, I guess periodically look in the file and see if anybody's sent anything.
- M: Well, yeah, your machine has to be on to to receive it, so.
- N: I'm gonna leave it on.
- M: Ah!
- N: Aren't you?
- M: Um, well I haven't, no.
- N: Oh really? Well, how'm I gonna send ya stuff?
- M: Well . . . I dunno. [laughs] I left it on all the time, um, but we can do that, or send it on a certain schedule?
- N: Yeah, well, you wanna work out a, like, sort of daytime hours, or something?
- M: Uh, that's fine.
- N: Yeah? Like, I dunno, 9 to 5? [laughs]
- M: [laughs] That sounds a bit extraordinary!
- N: [sigh].
- M: Maybe 9 to 10.
- N: Oh, I see, you don't, are you [pause] something else then?
- M: Oh, I, uh, it just seems kinda, I dunno, I mean, it just seems kinda strange to have it on all the time.
- N: I thought we weren't supposed to turn it on and off all the time. [Pause] I dunno,

well we should figure that out, figure out what we're gonna do, ask Rob how he wants the equipment [Pause]

M: Well, he'll set up a schedule for himself.

N: All right! Very good. Ok, anyway. I'll call you before I fax this. [laughs]

M: [laughing] No, no, no no. I'll leave it on every morning, how's that?

N: Well, ok. Good. So I can fax you something in the morning, but not in the afternoon?

M: [laughs] OK.

N: That's good, well I mean, then I know if I'm going to do it some other time, I should ring you first. And I'll do the same. If I can keep my wits about me. [Pause] So that should be clear.

During the period of learning the new technology, participants had explicit discussions of what a particular channel might be used for. Unlike the discussions focused on the best channel to choose for a given task, these discussions looked at a particular channel, and considered what use it might have. The Chat functionality was particularly productive of such discussions:

K: When would we ever need to use **this**? If we had laryngitis or something and couldn't talk?

### **5.2.3**

#### **Shared space and communication veils**

As part of cowork, people organize their resources and materials so that they can both share work and keep some of their materials and activities private. This is a major factor in deciding which of the multiple communication channels available to them they will use. Establishing public and private space, as well as a common focus of attention, is a necessary part of cowork both in face-to-face and computer-supported communications.

We tracked the way users take advantage of the various degrees of privacy available on different channels. The bandwidth capabilities of various communication channels result in "communicational veils" that allow different

organizations of work tasks and conversational activity. For example, when people communicating at a distance do not have the visual link afforded to them by face-to-face conversation (or presumably, video conferencing), we observed that they engage in much more parallel work on unshared tasks (e.g., reading mail, checking lists, shuffling through folders, preparing next-topic agenda items). This additional work can not be seen by the other partner, and hence is not problematic in the interaction. In a face-to-face interaction, such work would be seen as off-task, and hence disruptive or rude.

However communication veils are not confined to cowork at a distance. In face-to-face meetings, communication veils can still exist in the organization of papers and artifacts that are more or less shared, such as slides projected on the wall, personal notebooks, etc. We observed that in face-to-face meetings, participants tacitly define shared and personal space in their work area. For example, when the GG participants worked jointly on a design, they used the space in the middle of the table as joint space. An object placed there could be manipulated by any legitimate participant in the meeting. By contrast, the space directly in front of a participant and the materials placed there were considered private. Participants did not lean over to pick up or even look at something in the space in front of another participant. Indeed, we found that participants took advantage of this division of space into public and private to facilitate the course of meetings. A participant moving something placed in public space back into private space served as a preclosing marker, an indication that the discussion about that document is potentially at an end. As discussed below, this organization of shared and private space has significant implications for design.<sup>8</sup>

#### **5.2.4**

##### **Design implications**

Most of the technologies which have been developed to support cowork are based on a number of assumptions which are, in fact, inadequate or false: people talking on the phone are completely attentive to the conversation; people meeting together in one room are necessarily focused on one task; the more bandwidth the better for communications between remote locations, etc. Our research showed that instead of being designed around such unfounded assumptions,

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<sup>8</sup> Issues discussed in this section are developed in Linde, forthcoming

technologies intended to support real-time interactive cowork must be responsive to the actual ways in which people negotiate communication, ownership of materials, direction of attention, and many other primarily social organizations of work. Understanding these negotiations gives us a way to evaluate the affordances and limitations of technological supports for cowork.

Video links, while superficially appealing, are not the primary solution. More subtleties are needed for communication channels. In particular, we must find ways to maintain both public and private spaces at the same time. For the design of systems, this means providing different types and degrees of sharing, as well as information and control over the extent to which things can be shared or owned. (For example can user A "show" user B something electronically without B being able to copy it?) Moreover, these designs must be managed in real time, rather than established at the beginning of a session.

Thus, in contrast to the common technology-driven assumption that increasing bandwidth "increases the communication," more complex mechanisms are needed—mechanisms for managing the ownership and status of information as well as for managing ways to share documents and processes. Being able to choose only between all or no remote screen sharing or observation (available in some commercial products) is too crude and allows only extreme choices that do not respect the subtlety of the communication needs of coworkers. In any design that is responsive to these findings, there will be complex social consequences to how these shared workspaces are managed by users. Tracking these conventions through further study of the adoption of such tools will be crucial to a better understanding of this complex question.

### **5.2.5**

#### **Research implications**

The subtleties of cowork which our studies reveal have serious implications for the nature and the focus of future research. For instance, discussions among either our designers or our participants about what a channel might be good for did not in fact reliably predict how it was used. In particular, users can not predict their own patterns of use. For example, although users at both our sites commented on the probable uselessness of the Chat functionality, they all used it. This is yet another piece of evidence in favor of research in a natural work setting, and against an exclusive reliance on such methods as focus groups or simple user-centered design.



### 5.3: Social negotiation of attitude toward technology use

We observed that in the course of people learning and using a technology together, they provided all kinds of evaluations of the technology, favorable and unfavorable. This seems to be particularly the case for new technologies. Indeed, the point at which people no longer evaluate it regularly or strongly, may mark the achievement of transparency for that technology in that community.

We found examples of people praising or vilifying a whole technology or features of it, in the process of explaining or using it. We also found people offering articulations and explanations of their expertise with the technology, or their lack of it. This phenomenon is particularly important for understanding the way in which the introduction of a new technology alters the social system into which it is introduced, as people who were previously equals may become differentiated as experts and nonexperts on the new technology; or as someone's role becomes more important in the community through the development of unique expertise.

In particular we found examples of the social negotiation of the evaluation of technology. The term *negotiation*, as we use it here, does not refer to a formal negotiating session around the bargaining table. Rather, it refers to a kind of low-key argument, a moment-by-moment process in which a speaker indicates an evaluation, and other participants agree or disagree. This may lead to change on the part of one or more participants in the way in which they evaluate the technology.

Such a process is familiar in discourse analysis. In the study of narrative, it is well known that evaluation is perhaps socially the most important part of what is going on (Labov, 1972; Polanyi, 1989; Linde, to appear). The decision on what a story means is produced not only by the speaker, but by the conversation between the main speaker and the addressees. An addressee may show understanding and agreement of the speaker's evaluative construction by providing an evaluation during the story, or may dispute it, in which case the two must negotiate some ground for agreement before the narrative can proceed.

A spontaneous tutoring session in one of our research sites provides an example of the phenomenon we are describing. In preparation for the installation of the Picasso system, one of the people who would be using it decided that she should learn the Macintosh, since at that time she only knew how to use the Apple II, a very different machine. She asked a secretary in the main office to teach her.

She chose this person because the latter was widely known to be good at the system (This event is also a nice illustration of the ecology of knowledge: in a workplace people have a well developed sense of who has what knowledge, and who would be competent and willing to teach it.) In the course of the tutoring session, the "tutor" repeatedly praised the technology, for being "easy to learn." An example of such praise comes as the "student" asks how to format a disk, and the tutor's first response, before showing the procedure, is a praise of the way the Macintosh does this.

Student: S, I don't know how to do that.

Tutor: It's so simple ladies.

We view this as the tutor's stating her evaluation of the system, which she proposes that the student might share. Thus this interaction can be seen as the beginning of a negotiation about how this group feels about the technology. The tutor gives many such indications of how to evaluate the technology. As a response to such evaluations, the student may agree or disagree, either explicitly, by silence, by withdrawing from the session, etc. About 25 minutes into the session, as the student is trying to type a company newsletter, she discovers the possibility of changing fonts and type sizes. At this point, she offers her own evaluation of the technology:

Student: Oh I can have fun with this little machine.

At this point, we judge that the negotiation has been successful: the student has apparently come to share the tutor's proposed attitude toward the technology.

We can not say, of course, what the student's evaluation means—that she actually feels this way—only that she is willing to say this kind of sentence. If we had to predict from just this interaction, however, we would be willing to say that there is a good chance that she actually will learn the technology. Certainly, it is more promising for learning than a speaker saying:

Oh, it's just too hard.

In fact, what happened with our student is that she did in fact learn the Macintosh system, which she had heard praised, although it was a long process, with many detours into such negative evaluations as:

I don't want to be computer literate.

Finally, when her firm bought a number of Macintoshes, the question came up about whether to keep or discard the remaining Apple II. The manager was in favor of keeping it, for reasons of thrift. But this student argued that they should throw it away because the Macintosh was so much better. We view this as a final testimony of the success both of the learning process, and of the negotiation of evaluation which initiated and pervaded it.

### **5.3.1**

#### **Discourse functions of evaluation**

We have sketched the role of evaluation in whether a new technology is learned or not. We now turn to the kinds of discourse in which such evaluation is embedded. We are not concerned here with the evaluation of design features that may make a technology learnable, but rather with how evaluation of technology works within the larger context of interaction. This helps us understand the details of the practices by which a community of practice aligns around or against a technology.

In our data, evaluations of the technology are very common. They range from long explicit discussions of the value of the technology to incidental comments on it in the course of an interaction focused elsewhere. Below we consider the most common situations of evaluation. These are:

- evaluation in the course of explicit focus on the technology
- evaluation in the course of explicit focus on relations within the community of practice, with technology use as a subordinate part
- evaluation as part of ongoing interaction.

#### ■ 5.3.1.1 *Evaluation in the course of explicit focus on the technology*

In some cases, evaluations occurred in the course of exchanges in which the explicit topic of the discourse was some feature of the technology. There were a number of ways in which such explicit evaluation took place.

The first was an explicit and extended evaluation of a technology by one person.

N: [to M] We wanted to send this page to Rob.

M: Um-hm.

N: Theoretically we could put this in the scanner and we could send **this**.

M: Um-hm.

N: So you can send hard copy, it looks like we can send copy from the screen, or we can send hard copy, which is fabulous! It's **fabulous!** What a great set-up! [softer] . . . if it works.

The next is a negotiation by a group of the value of a technology. These may include disagreements in the evaluation, which may or not be resolved. In the example below, a group of users discuss whether the Chat functionality is valuable. Their evaluation turns on whether it is possible to print out the results of a Chat session, and they discuss whether this is in fact possible.

M: I don't know that the Chat function is all that useful.

T: Yeah, takes forever just to get through.

M: Can you print their answers? I think [XXX].

M: Oh, yeah, get them on paper [XXX]

All three laugh

S: You ask 'em all these questions, ya wanna be able to [Pause]

T: Yeah, there ya go!

M: Yeah, y'know, I wonder. Has anybody [

S: [But see, actually, no:. Well, you see it'll be all on your disk, wouldn't it?

M: Well, I dunno [XXX] get in here maybe it can save it or not, I dunno.

T: Yeah, if you wanna get everything on [XXX] kind of, [well, yeah [Pause]

S: [It's like typing the phone in [XXX]

M: Y'see, I don't know if there's a, if you can save what you type, or anything. [XXX] Maybe, y'know. [XXX]

T: Well, it's just not [

★ pages 71 + 72  
are missing

K: Hahaha. We're taking an hour just to have a phone conversation.

■ 5.3.1.3 *Evaluation as part of ongoing interaction*

We found some evaluations occurred in the background of interactions that are focused on other topics. Our examples are less immediately striking than the previous ones, but they may be more important. They show an ongoing process of low-key evaluation that is constant and pervasive, and that probably serves to establish an environment of welcome or hostility to technology in general within a given workplace or community of practice.

One form of such backgrounded evaluation is evaluation as a preclosing marker for a section of discourse. We have found that one very common way of ending an agenda item at a meeting is by an evaluation of some feature of the discussion: whether it is the work that has just been done, the plans that have been made, or one of the topics discussed. One form of preclosing is an evaluation of the prior discussion. Rather than continuing the topic, the speaker steps back from it to give an indication of what it means, what its value is, etc. Such evaluations may be simple statements like

Well that's OK.

Good for you. I'm glad that that worked well.

These often involve the use of proverbs, aphorisms, etc. Or they may be elaborate and detailed evaluations of the entire topic. For example, in discussing a client's desire to repeat his name on every page, the two designers have agreed that three repetitions is enough. Then the participant who is not the designer of this project provides the following evaluation, a summary of the preceding discussion which serves as a preclosing:

N: In fact, I think you sort of shoot yourself in the foot, if you are too obvious.

Evaluation of the technology is a particularly common form of the use of evaluation as a marker of the end of a section of discourse. In the following example, the participants have explicitly agreed to close their working session. They end this negotiation with an overall evaluation of the new technology.

M: All right now, are there other things we  
wanna try here?  
N: Uh, lemme tell you something.  
M: OK.  
N: I dunno about you, but I'm getting tired.  
M: Yeah.  
N: It's been sort of a longish time.  
M: OK.  
N: This is not a bad learning session.  
M: No: [XXX]  
N: It's a lot of fun, and maybe we're going to  
uh, experiment some more later or  
something.  
M: OK. It seems like everything's really  
working very neatly so far.

Another placement for evaluation of technology is as a filler. The Picasso system imposes waiting periods during the transmission of files and faxes, and for some screen sharing uses. If the participants are also using the telephone, they face the problem that their ongoing work interaction has been suspended until transmission is complete, but the conventions for conversation, particularly telephone conversation, make long gaps undesirable. Such gaps may be filled by evaluation of the technology. In the example below, as N waits to receive a fax, she gives her evaluation of the delay: it is noticeably long, but better than the hour drive it would take her to drive to get the document from her partner.

M: Okay, you can read it I gather.  
N: I haven't got it yet.  
N: Yeah, this is just kind of a time consuming  
ah . . . I mean it's obviously a lot better  
than a trip up to Berkeley, right?  
M: Uh, yeah, and once you know you have hafta  
be patient you don't hafta [Pause]

This sort of evaluation is a common strategy for dealing with long conversational pauses. When a conversation has come to a momentary halt, one way of reviving it is to take notice of some feature of the environment. For example one might comment on the scenery or a passing bumper sticker during an automobile trip. In the interactions which we studied, perhaps the most

striking feature of the environment is the Picasso technology, so it is quite plausible that participants fill gaps with evaluative remarks about it.

Note that we are not studying the content of evaluations. It would be a simple and familiar kind of study to count up negative versus positive evaluations, and attempt to predict the success of a design from the ratio. However, for this study, the design of the study itself had effect on the distribution of kinds of evaluation. That is, these evaluations occur during filmed work sessions. The participants knew that the people doing the filming were part of the team that designed the technology and that the rest of the team would be analyzing the video. This made them more likely to praise the technology than to criticize it. As a consequence, their criticisms are, of course, all the more interesting. But the existence of the bias precludes a quantitative study of the content of the evaluations.

### **5.3.2**

#### **Design implications**

The attitude which a community of practice holds toward a technology makes a very important contribution to whether a person will learn a new technology. The social negotiation of attitude represents a process by which a person is inducted into the community technology use. Evaluation is also important in beginning a new cycle of technology use by the community. The evaluation of the virtues or vices of a technology is a precondition for the successful or grudging learning of that technology. Comments such as

It's just wonderful, ladies. You're going to love it

or

Well, actually, no-one's been able to figure out how that part works

have dramatically different implications for whether a device is accepted or rejected. Of course, the relevant evaluations must come from a community of practice of which the learner is a member, or wishes to become a member. A clerk with no computer training is not likely to enter into a negotiation of attitudes about a technology with someone that he or she believes to be a technical wizard and not a member of the same community of practice.

Three design implications of this finding address the question of what sort of resources for learning designers and corporations should provide. First, as we argued in a different context in section 5.1.4, instructional matter should comprise a variety of levels of expertise, so that the learner can choose both the level appropriate to his or her own community of practice and the level appropriate to his or her position within that community. Second, this research suggests that the best instructors come from within a given community of practice. Thus when a corporation sets up support services for a technology—help hotlines, training, etc.—these should be staffed by personnel whom learners can see as part of, or similar to members in their own communities. Third, an option that falls somewhere between the first two, video or compact-disk technology might be used as an introductory vehicle for new tools that includes social modelling of attitude toward the technology in the context of carrying out cowork tasks.

### **5.3.3**

#### **Research implications**

Within learning research, most of the attention has been focused on involuntary learning—learning in situations in which the learner has no choice. In a school setting, the canonical case for learning research, the student really cannot choose whether or not to learn to read. But particularly in learning new consumer devices, and even to some extent in the learning of new office technology, there can be a significant degree of choice. Study of the social negotiation of attitude is the beginning of the study of voluntary learning, and what helps or impedes it. Voluntary learning is an important attribute of successful learning.

Within linguistics, research on the social use of narrative has shown that narrative is an important resource because it allows speakers and addressees to negotiate the meanings of events. The current research allows us to extend that description from the evaluation of past events to the evaluation of proposed and ongoing events such as learning.

## **5.4: Meeting and agenda management**

In informal meetings—meetings in which there are no prearranged agenda, order of speakers, chair, etc.—the order of the meeting is constructed by the



participants, moment by moment, in a process of informal negotiation.<sup>10</sup> As discussed in 5.3, we do not use *negotiation* to mean a formal negotiating session around the bargaining table, but rather a moment-by-moment process of people displaying and aligning their attitudes about the interaction. Meetings are negotiated at a variety of levels, including:

Purpose: Sometimes, but not always, there may be a negotiation of the purpose of a meeting. The more regular meetings are for a given group, the more likely that the purpose of an individual meeting is conventional and known to all the participants. Here negotiation is not necessary. Negotiation is more likely with new meetings. For example, in initial sessions with the Picasso prototype, we saw negotiations about whether the meeting would be to learn the new system or to be try to get actual tasks accomplished.

Structure: Meetings typically begin with an opening section of greetings and social exchange. If there is an explicit negotiation of the purpose of structure of the meeting, it comes next. This is followed by the actual work session. Finally, there is the preclosing negotiation, and then the actual closing of the meeting. How many of these sections are actually present and how fully developed they are depend on the relations between meeting participants, and particularly, on how often they meet. If they meet sufficiently often during the day to be in an "open state of talk" (see section 5.5.1), they may dispense with opening greetings and talk and proceed directly to the agenda of the meeting. Preclosings (see section 5.4.1.2) may be quite elaborate: we observed one 40-minute phone meeting where the preclosing negotiation begins at least six minutes before the participants actually close.

Task assignment–Follow up: This is the negotiation of what tasks need to be done, based on the work done in the meeting, and the determination of who will do them, either during or after the meeting. Negotiation of task assignment may form part of the negotiation of the closing of a given agenda item. That is, one natural way to indicate that a topic is coming to an end is to indicate that additional work must be done that cannot be done on the spot. In addition, task assignment may form part of the preclosing negotiation for the entire meeting. Participants will typically review what tasks each has promised to do just before they close.

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<sup>10</sup> Issues discussed in this section are addressed in Linde, in press (Picasso Publication 6) and Linde, forthcoming.

Implicit in each of these levels is the notion of an agenda. By the agenda of the meeting, we mean the actual topics or tasks that are worked on. In what follows we focus on this level, since it is the level where the major interactional work takes place and hence the level with the most immediate implications for design.

#### **5.4.1**

##### **Agenda Management**

By placing our analysis at the level of agenda items rather than of individual topics, we are able to avoid the difficulty of providing a general definition of the notion of topic by taking advantage of the particular structure of GG's meetings. These meetings had a macrostructure of agenda items which consisted of separate discussions of individual projects. We therefore consider the work of achieving transition from discussion of one project to the next, ignoring topic structure within projects. This offers a good overview of agenda management and can provide suggestions for the later study of topic management within projects.

Another factor which makes agenda management at GG valuable for study is that their typical work practice does not include an explicit joint agenda or to-do list for meetings. In some of their phone meetings, one participant had a list of topics, but this list was not shared, either in writing or orally with her partner. A topic list could have been distributed before the meeting or announced at the beginning of the meeting, but neither of these strategies was used. We know, however, that the participants had prepared for these meetings since they brought to phone and face-to-face meetings folders containing work on the projects they expected to be discussed. In separate interviews on their work practices, the participants each said that they did not prepare a specific agenda because they worked on few enough jobs that they could keep track of all of them and knew which needed to be discussed. Since they combine to require explicit work by participants during the meeting to constitute the agenda, these work practices make these data particularly valuable for the study of agenda management.

As we shall see, agenda management is a negotiation between meeting participants usually involving:

- topic introduction
- topic closure

■ 5.4.1.1 Resources for topic introduction

Either at the beginning of a conversation, meeting, etc, or after the previous topic has reached a point of possible conclusion (see section 5.4.1.2), participants may introduce a new topic. They have a variety of resources for this including:

- explicit agenda calls
- explicit topic proposals
- physical introductions of topics

Let us consider these in turn, using the data we gathered at meetings of GG.

Explicit agenda calls (also called "topic elicitors" by Button & Casey, 1984):

These are explicit requests by a current speaker for the introduction of a topic by other participants. Examples included:

What's next?

OK, what else, what else do we have to worry about?

So anything else? Are we missing anything else?

If the other participant does not immediately propose a topic, the speaker issuing the agenda call may then introduce one. In more complex cases, the agenda call may propose a number of topics, thus projecting future topics for at least part of the conversation.

N: Let's see. I don't know whether we should talk about [Pause] [Q] is gonna be our toughest one. Shall we just leave that for last and go through this other stuff first?

M: Fine

N: Well let's, I, I don't know. This is not easy either. If we leave. [Pause] This is [O]'s stuff. These are all sort of chaotic at the moment. Well OK. This is [E]'s.

Explicit topic proposals: While agenda calls request a next topic, topic proposals explicitly indicate that what follows is a new topic. Examples included:

On to [Q].

So I'll show you my stuff here because this all kinda, that's nothing. This is all kinda straightforward.

And this is Mr. [T]

You want to see the IRL bid?

Such topic proposals may be either accepted, postponed or rejected.<sup>11</sup>

Physical introduction of topics: These include getting a folder, opening a folder, touching a folder, etc. In general, we find that when there is a physical topical proposal, it tends to precede its corresponding linguistic topic proposal. (This is entirely consonant with the research on gestures, which finds in general that gestures tend to precede their accompanying linguistic material (Moerman, 1989; Schegloff, 1984; McNeill, 1979)). That is, we argue that the physical manipulation of folders is communicative as well as instrumental.

#### ■ 5.4.1.2 Resources for topic closure

Next, we consider not how a new topic is introduced, but how the previous topic is closed. Resources for accomplishing topic change include

- preclosing markers
- explicit topic closings

Preclosing markers: These are indications of the possibility of the appropriateness of ending the current topic. These include discourse markers like "Well," "OK," "So," etc, offered as the speaker's entire turn. As (Schegloff & Sacks, 1973) describe the function of these markers:

With them, a speaker takes a turn whose business seems to be to "pass" i.e. to indicate that he has not now anything more or new to say and also to give a "free" turn to a next speaker, who, because such an utterance can be treated as having broken with any prior

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<sup>11</sup> See Linde (1988) for a discussion of the relation of the linguistic form of the proposal to topic success and failure in the domain of aviation accidents.

topic, can without violating topical coherence take the occasion to introduce a new topic.  
[p. 304]

Such preclosing markers tend to come in pairs:

OK. OK.

Well [pause], well [pause].

These indicate that both participants have passed on the chance to continue the current topic. Another form of preclosing, as we noted in section 5.3.1.3, is to evaluate the prior discussion with remarks like "that's OK" or with a proverb or aphorism.

In the context of a work meeting, another very common form of preclosing is for the speaker to refer to work to be done outside the meeting or to suggest future actions by other participants. These function as preclosings since they suggest that it is not currently productive to continue discussing the topic until the proposed work is completed:

Right. Well what I was going to do is finish these up as this round of the variations on the theme as best I could and send them off to you. And then you could [pause] look at them, fiddle with them while I am gone.

This strategy for preclosing thus ties the current topic not only to the agenda of the current meeting, but to future actions as well.

In a face-to-face meeting, there is also the possibility of using physical movements to serve as preclosing indications. These may be as subtle as postural shifts forward or backward in a chair, or as obvious as looking at one's watch or taking out and playing with car keys. In the work meetings studied here, since the participants' work involved designs, which they brought to meetings to show to one another, physical indications were readily available to the participants and played an important role in topic management. One obvious method to indicate the possible closing of a topic was to close the folder containing the work under discussion. A more subtle indication was to vary the pace of moving through the individual papers in a folder: fast shuffling through a

pile indicating that the rest of the pile is not very important and so the topic may be seen to be coming to a close.

It might be argued that closing a folder is part of the efficient organization of the actual work being performed, and hence it is an overinterpretation to view it as a communicational move. When we compare how the participants manage folders in face-to-face meetings and phone meetings, however, we find that in phone meetings, folders are often left open after their corresponding topic is closed and are closed either at the end of the meeting or during the discussion of some unrelated topic. This argues strongly that folder management in face-to-face meetings is in fact used as a resource for communication. This resource management is elegant, but not surprising. Linguistic research indicates that any difference that can be distinguished by participants will be used to communicate some linguistic or social meaning.

Explicit topic closings: In addition to preclosings, there are also explicit markers of topic closing. These almost always follow the negotiation process of preclosings. Farewells are an example:

OK. Bye bye. Bye.

Within a meeting, there are also explicit closings of a particular topic:

OK, That's all I have to say about [O].

In our data, explicit topic closings are quite rare: two in 34 topics. It is interesting to note that both of these are offered by the owner of the agenda item.

#### **5.4.2**

##### **Participant structure of agenda negotiation**

We have shown that the management of the agenda is a negotiation between the participants. It remains to be seen whether participants have equal rights and function in the same ways.

It is not possible to focus on one participant as accomplishing the entire topic change, since there is a joint negotiation to establish that a prior topic is closed and that the introduction of a new topic is appropriate. In this situation, however, we can distinguish project owners. There were certain rights to the topic which only the project owner has. One was the physical ownership of folders and documents. While these were shown to other participants, control

always remained with the owner. We found no instances of a participant opening, closing, or removing documents from a folder owned by another—except in a case where the document's owner had already offered it for viewing. In terms of agenda management, this means that the project owner uniquely had the resource of physically signalling a topic closing or opening. (See section 6.2 for a further discussion of the design implications of this kind of partial sharing of material understood to be owned by one participant.)

Also, with few exceptions, it was the project owner who introduced a project as a topic. It might appear that this is entirely obvious, since it was the project owner who knew what state the project was in, and whether it constitutes a topic. In conversation, however, it is a sign of intimacy to know one's interlocutor well enough to ask about some scheduled event or problem:

How did your doctor's appointment go?

In the case of GG, where there are relatively few projects at any given time, this type of topic introduction would be feasible, but in fact, we found only one case, in which a project was introduced by a nonowner, and this was only after a long sequence of preclosings which appear to be closing the entire telephone meeting.

N: Thanks, sweetie. It's good // to talk to you.

M: Yeah. Be in touch.

N: Thanks for getting all that [T U] stuff to me.

M: Oh, well, uh, it's uh, it was not uh, it was just a matter of, as usual, these continual changes.

N: Changes. Yeah.

M: Other than that, it was [Pause] // straightforward.

N: Oh, listen, did we ever get copies of the print shop?

M: No, I wrote to him, I, yeah, wrote to him when I sent him his last uh invoice, and asked for copies. So, I'm sure we'll hear from him.

Finally, while both participants introduced preclosings, it was only the project owner who introduced formal topic closings.

A further aspect of participant structure is determined by the assignment of tasks to be done before the next meeting. The following is the one case in these data in which the nonowner reopened the topic once it had been formally closed, in order to check on what it was she agreed to do.

N: I don't think I need to. I mean it's, I've already, I've already spent so much time on it that it's kind of, I mean, I don't mind doing it, I'm glad to help her out, but. OK, what else, what else do we have to worry about? Oh.

M: Well, I, just to get back to [O] for, //for a minute.

N: Oh, I'm sorry. I thought we were done with them.

M: Well, I just uh, wanna get s:traight here, what I'm, what I'm doing.

Agenda management does not differ greatly between face-to-face meetings and telephone meetings. Although the physical resources for joint agenda management are not present, participants make a similar use of linguistic resources to negotiate the same topic changes. The one difference that we did find is a greater use of "agenda calls" in phone meetings, such as

OK what's next.

Participants go to a meta level, making specific reference to the conduct of the meeting. Although the number of cases in our data is too small to yield significant results, the difference is in the expected direction: absence of physical resources for negotiation requires a more explicit use of the available linguistic resources. We did not, however, find a greater use of preclosings or explicit closings in phone meetings. Nor did we see Picasso fax or file transfer functionalities used to introduce new agenda items. This is probably because the timing of these functionalities can not be precisely adjusted to the timing of a telephone conversation. Therefore the telephone channel was always used to negotiate whether a file or fax would be sent. The Chat functionality was sometimes used to introduce new agenda items because its turnaround time was short enough to permit this.



### **5.4.3**

#### **Design implications**

One major issue for the understanding of meetings is to determine the various levels of meeting structure and to recognize just how they are negotiated. This will allow us to design communications technologies that take advantage of meeting structure, rather than technologies that violate it. We attempted to build these insights into the design of Picasso 3.0 (see section 6.2). The understanding of meeting structure is also more broadly applicable to the design of groupware that will support the ways in which groups actually work.

### **5.4.4**

#### **Research implications**

At the research level, the meeting is a discourse structure which has received very little study to date, though meetings are as common as dandelions. Understanding this structure is important for linguistics, for conversation analysis, and for management and business studies, since it forms one of the major ways in which people communicate with one another and accomplish tasks in the world.

## **5.5: Ongoing activity and the structure of turntaking**

To understand communications technology like Picasso, it is important to know how it works with existing social conventions for communication. One of the most important sets of such conventions are the conventions for turntaking, which can be viewed as the traffic rules of conversation. These rules were first set out in Sacks, Schegloff, and Jefferson (1974) and have received a great deal of study since that foundational paper. Thus far, these studies of interaction and turntaking have focused on what we may call recreational conversation. When people are simultaneously talking and performing other tasks (whether those tasks are physically or electronically based), the way in which they take turns looks quite different from turntaking when they are engaged primarily in conversation. Pauses both between and within turns are longer; people appear to move their attention into and away from the talk as they turn to other activities without apology for their absence; mutual eye gaze is not maintained; and people begin and end conversations without greetings or farewells.

### 5.5.1

#### Open state of talk

To show what this sort of interaction looks like, we here describe a few minutes from our data in detail. (We use a description, focusing on the phenomena of interest, rather than a full transcription, for ease of presentation.) In this example, taken from a face-to-face meeting at HELP, L, the supervisor, and K, her assistant are working together in L's office. K normally works in her own office at a site 11 miles from L's office. They speak to each other on the phone several times a day, and meet in person several times a week. This is a meeting which they have arranged after a few days of not seeing one another.

K is alone in L's office, using the phone. L walks in while K is on the phone, standing up. K swivels to face L, but L does not look at K, rather she immediately looks at her desk, then walks past K. K finishes phone conversation, walks past L toward her own papers on the table on the other side of the room without looking at L. L turns, starts to talk to K, 10 seconds later, without establishing eye contact. They continue conversation while moving around the office, getting files out of cabinet, etc. Eye contact is first established 59 seconds after L has first walked in, and 49 seconds after they have begun their talk.

During this talk, there is a 10 second pause in talk, with no pause fillers, or explanations that an activity has preempted the talk. L searches for a document on her desk. Talk resumes for 10 seconds, without eye contact, then an eight second pause. L puts a document in an envelope, K searches in file cabinet. Talk resumes, at first without eye contact. Eye contact is established at 03:00. K torques to look at L for nine seconds, from 03:00 to 03:09, then returns to looking at her list. L has her chair half swiveled in to the center of the room, but her upper body is somewhat torqued to face K. She then turns back to her desk at 03:21. At 03:33, L swivels again to face K, who is still looking at her list. At 04:07, K says "Drop those things off and then basically I think I'm done with this."

What is striking here is that these people seem to be moving in and out of what we would call normal conversation. Indicators such as body alignment, eye gaze, pause timing, absence or presence of pause fillers, and presence of other activities sometimes look like what we would call regular conversation and sometimes like something different. That something different, we call an "open state of talk" (OST).

We define the OST as a context of interaction in which it is expected that the entire interaction is timed not only by the rules of conversation exchange, but also by physical task demands and responsibilities to other interlocutors, which may interrupt the talk. Thus, it is a context of interaction in which the talk is

not is not talk-driven talk, but task-driven talk. "Driven" here refers to the dominant activity, the activity to which participants orient as most salient or privileged, and which is serving simultaneously to time other activities.

There are a number of factors that permit the establishment of an OST. These are

- social
- physical
- technological

#### ■ 5.5.1.1 *Social factors*

The people interacting with one another are in a legitimate relation requiring continued copresence. That is, they know that their relation requires that they will continue to be together. Furthermore, they have not come together on this occasion just for the sake of being together. The relation of being coworkers or members of the same family living in the same dwelling establishes the possibility of an OST.

(The notion of a "legitimate relation requiring copresence" explains the unease in conversations with airplane seatmates, for example.) It is unclear whether there is a conversation or as an OST. If they are not in an OST, then it is an ordinary conversation and and rules of conversational etiquette require that they must carry it on without gaps. If they are in an OST, then they may stop and later resume talk without a need to mark or apologize for those gaps.)

#### ■ 5.5.1.2 *Physical factors*

There are factors of physical space and conventions for using that space which facilitate copresence, and hence the OST. For example, open-plan housing or offices facilitate an OST, while spatial arrangements of many small rooms facilitate bounded interactional contexts, especially if the convention in a particular workplace is to keep doors shut. There are instances of workers subverting spatial arrangements in order to get the kind of interactional space they need. Zuboff (1988) cites a case of workers at adjoining desks who needed to be in an OST cutting holes in newly installed partitions to maintain it.

### ■ 5.5.1.3 *Technological factors*

Technological resources now permit degrees of simulation of copresence. Telephones, videophones, video conference tools, and computer resources such as e-mail, real-time Chat functions, and remote screen sharing all provide differing bundles of the features which can permit the maintenance of an OST. One way we attempt to sort these degrees of simulated copresence is by distinguishing live, dead, and passive links. A telephone hookup with a person engaged in conversation on both ends is a live link. Paper mail, e-mail, and network television are dead links. A telephone on hold is a passive link—currently dead, but able to come alive again. Live links, depending on their turn-around time, simulate copresence. Dead links do not.

However, even when live links are provided, we found that it is harder to maintain an OST using technological resources rather than actual copresence. Participants had to use more markers to indicate what the state of their activity is. For example, in phone conversations where it is clear that other activities are going on—getting something the other participant has asked for, for instance—there are more linguistic markers of leaving and coming back, since the visual channel does not provide information about what the other is doing, whether the channel is still live, etc. The recent introduction of call waiting services at home has pushed the boundaries of the OST for telephone interaction and it is clear that conventions are just beginning to develop.

As we have defined them, examples of the OST are segments of interactions in which participants are engaged simultaneously in talk and other tasks. Such examples were particularly interesting during work meetings using Picasso in which the demands of the tasks could conflict with the requirements for keeping conversation going. For example, we saw cases in which speakers became aware of the length of pauses which their activities required and suspected that this might cause a problem for the interaction. In such cases, we found speakers negotiating whether to stay on the phone while trying to read a manual or search through the menus, explaining the activity taking them away from the phone, or reading a manual or menu aloud in the distinctive "talking to oneself" intonation which allowed one participant to understand why the other is not available for conversation. We noticed that when people could not project the likely length of an operation they had initiated on Picasso, they tended to pause in their

interaction and wait for the device to finish. As they became more able to project how long an operation would take—or at least to project that it would not be instantaneous—they tended to fill the gap with other work or social chat until the operation was concluded.

### **5.5.2**

#### **Design Implications**

The general issue here is to define the nature of turntaking in a task-oriented context. More specifically, the critical design issue is to determine how technology may support or hinder turntaking and hence social interaction in general. This can be seen as an issue of transparency—the "glass box" issue which framed aspects of the original Picasso Project proposal (see appendix 1). We distinguish two kinds of glass box transparency. In one case, a device is transparent because the user understands the way the technology works. In the other case, a device is transparent because it supports the way in which users work so naturally that it does not obtrude on their attention once it has been learned. In order for a communications technology to become transparent in this second sense, it must support natural turntaking, which is the basis of human communication. If it violates turntaking conventions too severely, it cannot become transparent.

Another important implication for design of communications technologies is that it is necessary to devote a great deal of attention to the effect of differing kinds of delays in possible communications technology and their effects on natural interaction.

A related implication is that users need reliable indications of what the technology is doing, and if possible, how long it will take. This allows participants to project what kind of interaction is possible during time they know they must wait. A simple example: following this analysis, the design of telephones would be improved by the incorporation of a signalling device which would allow a person who has been put on hold (or whose conversation partner has left the line to do some task) to walk away from the phone with the knowledge that a signal would call him or her back when the link became live again. Then the caller could determine whether or not to hang up depending on whether the wait would be too disruptive.

The implications of these findings on the proposed Picasso 3.0 design are discussed in section 6.2. They include backgrounding data-transfer functions so

that users may continue their interactions with the machine and one another without having to wait for a fax or file to be sent and giving usable indications of the time a process will take.

### **5.5.3**

#### **Research Implications**

This work also has important implications for research in linguistics and conversation analysis, since it extends the study of human conversational interaction to interaction with tasks, and interaction mediated by communications technologies. This is a necessary extension of the existing theory, since so much interaction in fact does take place under such conditions and the number and kind of communications technologies in use is constantly expanding.

## SIX: CONCLUSIONS AND FUTURE WORK

The Picasso Project grew out of a collaboration between a major multinational developer of consumer electronics devices, Philips N.V and a multidisciplinary research institute, IRL. The project focused both the interests and the resources of the two partners on problems relating to the learnability and usability of interactive multimedia communication (IMC).

In this section, we summarize the central implications—both for learning research and for corporate research and development—of the work completed in the project and described in the body of this report. We divide these under three headings:

- Learning and work in the workplace: Here we emphasize in particular important findings that we believe both conventional, individualistic cognitive science and conventional, predominantly human-factors corporate research overlook.
- Design guidelines for IMC: Here we direct our conclusions at the challenge of designing future learnable and usable IMC devices, once again highlighting the constraints and resources that our research and research methods made visible. In the spirit of the collaboration between research and industry, we relate our conclusions to the framework of ongoing corporate research in this area.
- Reciprocal Evolution and the corporation: Finally, we explore the relevance of the research method we developed for the Picasso Project to the sort of research corporations require for product-development.

### 6.1: Learning and work in the workplace

Our assumptions and conclusions about learning are laid out in detail in the earlier sections of this report (see, in particular, section 5.1) and in related documents both from the Picasso Project and from the Institute for Research on Learning. In this section we try to recapitulate the most central results in a brief and accessible manner.

## 6.1.2

### Shifting the focus of research

The central research assumptions of the project shifted the focus of attention from individuals learning tool functionalities (what is usually referred to as "bootstrapping") to members of communities learning to perform tasks with the help of a tool. This shift helped us to "see" several important situated aspects of the learning and use of IMC devices. In particular, it suggested the need to distinguish two levels of learning—learning at the "use level" and learning at the "organizational level."

#### ■ 6.1.2.1 *Learning and use*

How readily IMC workplace tools will be used depends greatly on how easily they can be learned. Learning new tools for ongoing tasks usually takes place in the workplace. Thus, whatever theories they may hold about "optimal" learning situations, designers cannot (and probably should not) expect a new tool to be learned outside of the normal working conditions. (To do so, after all, would introduce the extra and enormously problematic demands of "transfer.") Tools need to be learnable amid the cluttered environment of work practices and coworkers. This environment inevitably both demands and divides learners' attention; but it can also provides support for their learning.

At this thickly social level of learning and use—rather than at the more rarified level of tool functionality—individualized designs and the prescriptive documentation conventionally provided for learning them retreat before the requirements and improvisations of collective practice. More salient for the success of learning and use than these resources, then, are the resources provided by the structure of tasks and the collaborative processes of work and communication. Looking at new technologies in this light, we noticed four particularly significant aspects of learning:

Task structure: Learning tended to take place not so much in response to the structure of a tool or its related learning materials, but in response to the structure of tasks and nested subtasks.

Differing strategies: Learning was not a single or standard process.

Different coworkers, even when working together, preferred different strategies for learning.

Crystallization of patterns of use: If learning was not conducted according to standards envisioned by designers, neither was use. Some



nonstandard uses were highly innovative (see below). Others crystallized into particular patterns that, in the context of the relevant community, simply became the new, community-sanctioned standard.

User-defined functionality: Some nonstandard uses were quite innovative. These "new" functionalities, like the crystallized patterns, would often spread throughout a work community through conversation and exemplification, creating a subculture of use patterns.

#### ■ 6.1.2.2 *Learning in organizations*

At the organizational level, tools confront not just workplace tasks and their structures, but the larger structures of office life. These can both change and be changed by new tools. The organization is also central to analysis of learning because it provides many of the resources people rely on to help learn or work. The organizational perspective brings some unconventional aspects of learning to the fore:

Attitude: Both directly and indirectly members of the communities we studied made judgements about the tools they worked with. These judgements or attitudes strongly affected the way in which people learned.

Emergent expertise: As a community learned to use new technologies, it was not necessary for everyone to learn the same things—this would only produce redundant knowledge. Instead, members deferred to one another's strengths. Expertise became distributed across the community, emerging in unpredicted places. Nonetheless, people quickly recognized who had what facets of expertise. The distribution of expertise did not necessarily follow the distribution of social status or authority. When learners turned to coworkers for help, they had to take into account distribution of power as well as distribution of knowledge within the organization.

Expertise differentials: The uneven distribution of knowledge did occasionally lead to asymmetries of expertise in cases where it was more useful for members to be at the same stage. This led to significant pressure being exerted on those who needed to learn. Occasionally, however, this learning burden was taken up by some third party not normally part of the relevant interaction.

One important consequence of viewing learning within the contexts of both tasks and organizations is that together these perspectives challenge the conventional division of users into the naive and the expert user of a tool. Expertise is not

only a function of the task as much as of the tool, it is also a continuous variable rather than a discontinuous one.

The implications of this research into the nature of learning in the workplace for current and future design strategies are explored in the following two sections.

## 6.2: Design guidelines for IMC

The ultimate purpose of studies like this is to produce more learnable and usable technologies for real work settings.<sup>12</sup> The Picasso Project was not designed, however, to improve a particular commercial system or to build a new one. Rather, its purpose was to develop general insights into how to design communications systems for collaborative work. In this section, we discuss the design implications of the Picasso research for the design of IMC devices.

We also outline standards for computer and networking platforms that the design requirements entail. The Picasso architecture was heavily restricted by the infrastructure available. The prototype allowed inter-Macintosh communication over dial-up telephone lines. It operated at the boundaries of low-end computer and modem technology. More powerful multitasking workstations and network infrastructures like ISDN and Local Area Networks (LANs) could certainly solve some related problems. Many of problems we observed at our test sites, however, required much more complex responses than merely a faster processor, more memory, a high-speed network, or a parallel video channel. Greater bandwidth is not the answer to the central issues that emerged in the course of the project.

The major issues on which we focus here are:

- Shared and private spaces
- Coordination channels for cowork
- Collisions between social and technological conventions
- Negotiation of means of communication
- User-controlled resource management
- Status feedback

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<sup>12</sup> Issues discussed in this section are developed in Allen, de Vet, and Pea, 1991 (Picasso Technical Report 2).

- Live links and dead links
- Extendable multimedia facilities
- Flexible autoconversion between media formats
- Open system architectures
- Mail broadcast
- Crystallization tracking and guided tours

■ 6.2.1.1 *Shared and private spaces*

Currently screen sharing in Picasso 2.0, whether in "observe" or "remote control" mode, entails either sharing everything on the screen or nothing at all. Our participants, however, did not want to share all information. We observed this reluctance in face-to-face situations, where participants distinguished between documents which they showed to their coworkers and documents which they kept private. We also observed similar reluctance in computer-based situations, where one participant was reluctant to send a draft since it was not in a state to be worked on by a partner. Users need both shared and private spaces. Sharing should thus be at the level of a window or file (or any other entity that is an identifiable information unit), but not at the machine level. Hosts should be able to designate multiple entities with different settings and relationships for privacy. Guests should only see or manipulate shared entities and have no knowledge about private entities. These settings should be dynamic, and negotiable, as illustrated by the following hypothetical scenario (H=host, G=guest):

G: [while observing H's screen] Do you have any information on that client?

H: Let me see. Yes, as a matter of fact I do.

H opens a client report on the screen, and changes its setting from "private" to "view-only."

G: [viewing the document] I think we should bring the evaluation in the second paragraph up to date, don't you?

H: Yeah, I did this 2 weeks ago. [H changes its setting to "edit," which gives G control over the document]

G: [recognizing changed settings from visual feedback]: You want me to change it now?

H: Sure, go ahead. [G starts editing the text]

G: That'll do it.

H: [H saves it] Do you want a copy? [H sends a copy to G, etc.]

Standard and platform implications: This view of shared and private spaces has implications for window managers. Instead of just read ("observe") or read-write ("remote control"), the levels of sharing should offer more fine-grained settings—perhaps a range of settings predetermined by the tasks at hand and customizable by the participants. The unit of sharing should be any entity that is an identifiable information unit, including but not limited to windows and files. It is also important to provide real-time performance for screen sharing. Slow performance dramatically effects learnability, because people have real-time expectations from their own workstation's visual performance. Screen sharing, for instance, needs at least 10 to 20 times the current bandwidth of 96-192 Kbps to reach real-time performance. ISDN and today's LANs offer that higher bandwidth.

■ 6.2.1.2 *Coordination channels for cowork*

Picasso permitted the use of only one communication channel at a time. We observed many forms of communication breakdown that cannot be adequately solved with only one channel. For example, when exchanging typed messages with Picasso's Chat function one user cannot perceive the other typing a response until it is sent, and thus may decide to begin formulating a next turn in the exchange, only to discover halfway through that there is more from the previous turn on the way. We also observed two participants trying to establish a communication link at the same time. Each finds the other's system "busy" since it is sending and thus unavailable for receiving.

Communicators need a separate communication channel to know what the other is doing and thereby to keep a mutual work interaction coherent. This coordinating channel must have known conventions in order to mediate the planning of collaborative work successfully. A coordination channel function can act as a repair channel in case problems arise in the communication on other channels. It can also be used to negotiate who should initiate communication and to allow synchronization and sequential coherence of distributed activity. The phone line seems to present the best option, having the necessary properties of immediacy and synchronicity, in addition to having well known social conventions. The Chat function is neither instantaneous nor synchronous.

Standard and platform implications: Participants in our study used a separate telephone line as a coordination channel to synchronize their work. To allow integration with other channels, however, such a coordination channel should be an integral part of a Picasso workstation. This is an argument for ISDN, which also provides higher bandwidth communication channels than the current telephone system does. This permits real-time performance, which will be crucial for screen sharing and for audio and full-motion video.

■ 6.2.1.3 *Collisions between social and technological conventions*

Some communication channels violate established conventions of phone and face-to-face communication. In the current version of Picasso, there are profound difficulties during a Chat session with turn-taking, interruptions, gaps and overlaps, and even establishing identity of messages. For example, it is difficult for one person to know whether they are interrupting another, and it is impossible for a sender to know whether someone is available at the other end to receive the message, and, if someone is, to know whether that person is being interrupted in the middle of some other more pressing activity. We also observed situations where the Chat tool was used by a group at one end and group members took turns typing messages. This confused the person at the other end, since the person typing is not required to provide an identification. Conventions such as typing an introduction statement explicitly may evolve, but the problem could be avoided by building in a facility to allow easy identification for each participant.

Standard and platform implications: New conventions can evolve after the introduction of new technology, as has happened with verbal communication around the telephone. But they should not violate established social conventions of communication. For example, the Chat problem of unsynchronized turntaking needs either a facility to prioritize the Chat messages or a character-based (rather than buffer-based) message exchange. Similarly, different fonts could be assigned to each participant (not just each machine as is now the case) with a palette of names of current participants displayable upon demand.

■ 6.2.1.4 *Negotiation of means of communication*

The conventions that establish a connection in the first place, change it in the middle, or end it form a special category and play a significant role in human communication. Unlike normal phone communication, where it is the human who

answers a call, with machine-to-machine communication, it is the machine that answers the call. The human recipient can interfere only by disabling the dial-in access on his or her machine or, once the connection has been established, by activating the hang-up process. Similarly, there is no facility for negotiating the means of communication. For instance, while in a Chat session, the guest can start to control a session if the host has granted that privilege. Control privileges cannot be dynamically changed during a session. We would like the ability to negotiate remote control. For example, a window could appear on the host screen after the guest has indicated a wish to observe, asking "Is it alright to observe you now?" If the host approves, the observation is automatically established. If it is denied, no observation will be possible. This way one could dynamically negotiate the initiation of observations.

Standard and platform implications: The negotiation process is a special type of coordination of collaborative work. The coordination channel mentioned above is only one way to implement this. A facility that supports the negotiation of remote control is another way. However it is supported, the conventions for negotiating should be designed to conform to existing social conventions; they should not be driven solely by the design of the technology.

#### ■ 6.2.1.5 *User-controlled resource management*

In general, people should be able to screen in-coming information in such a way that resources can be devoted to the work at hand. For instance, in Picasso the establishment of a machine-to-machine connection interrupted ongoing work at both ends. This undermined the users' work practices.

Standard and platform implications: File transfer should be handled as a separate task in the background, freeing resources for other tasks. The underlying operating system must support multitasking, but ultimately, the user should be able to take control of resources. This control must be achieved in real time, not through lengthy menus which take a long time to set.

#### ■ 6.2.1.6 *Status feedback*

In Picasso 2.0 we exceeded the limits of acceptable delays, especially during screen sharing and the sending of large graphics files. The host machine occasionally appeared to be frozen when it was actually updating the remote screen, which took up to one minute. Operating the keyboard or mouse only made things worse, since those input events are queued up. With 9600 baud

modem technology, files were typically transmitted at a rate of 1 Kbps. Although the sender saw a progress window indicating how long the rest of a file transfer was going to take, the recipient has no clue of its duration and only knew that it is done once a rather small and easily overlooked "status" icon changed.

Standard and platform implications: Even with faster and bigger multitasking machines and better compression and decompression techniques, feedback on machine and network status, both visual and auditory, is crucially important. This is the area where details count and where future experimental studies in real work settings with time delay trade-offs would be valuable.

#### ■ 6.2.1.7 *Live links and dead links*

A "live link" is a connection via a synchronous communication channel such as the telephone that allows users to exchange information incrementally. A "dead link," such as electronic mail or file transfer, is asynchronous, delaying communication of a message until the sender explicitly requests transmission and the receiver explicitly requests reception. It is very important that there is minimal interruption of ongoing live-link exchanges. It must also be easy to establish a live link at any time. We observed participants using a separate phone to augment (or coordinate) their Picasso communication very frequently. It should be possible to transfer information in the background while having an audio or video channel open. Instead of true parallel channels, the network could offer some form of channel multiplexing. For instance, while sending a file, the sender could use the same phone line to engage in a Chat session. Packets of file data would be interspersed with packets of Chat message data. The file transfer should take place in the background so that the Chat session can take place in the foreground. Since the Chat exchanges are low-intensity, this could work with hardly any burden on the performance of either communication.

Standard and platform implications: There is a significant need for a communication channel manager to facilitate talk, sending documents, managing turns, and privacy; to augment the channels in order to indicate the various states of systems; and to manage privacy and other operations, including resource management, line conflict, and talking conventions. The network should support parallel channels, and the platform should support some form of multitasking. Instead of true parallel channels, the network could offer some form of channel multiplexing. Such multiplexing and multitasking techniques are

conceivable for audio and video as well, although the network demands would be much higher.

■ 6.2.1.8 *Extendable multimedia facilities*

Extending the communication to other media, such as animation, video, and audio, will put much higher demands on the system and its users. Sufficient network bandwidth and sophisticated compression and decompression techniques will definitely help. But once a multimedia document has been exchanged, constraints on viewing, printing, playing, and editing will become apparent. Problems will also arise when the available multimedia editing tools of sender and recipient are incompatible.

Standard and platform implications: The problem of asymmetric (or incompatible) environments can partly be solved by transferring self-launching documents, that is, by sending mini-applications along with and attached to the documents, enabling the recipient at least to view, print, or play them. More serious are differences in hardware platforms. Currently the information on media capabilities are statically represented in the phone directory of each sender. But that does not accommodate changes in the hardware environment. To support dynamic and automatic updates in media capabilities, a broadcast or polling facility is needed. For instance, if a person turns off the possibility of control, that change could be broadcast to others so that their phone directories are automatically updated. Any multimedia communication device must be designed with a growth path in mind. This path must provide room for other modes, like hand gestures, hand-written comments, speech annotations, speech commands, and full-motion video.

■ 6.2.1.9 *Flexible autoconversion between media formats*

To accommodate differences in system environment, graceful degradation from one media format to another is crucial. Messages like "Your computer cannot print the contents of this message" should be avoided. A set of format conversion tools, which in Picasso 2.0 only consisted of a tool to generate a fax document out of every text or graphics file, should extend across many formats, so that some representation of a message is available even if the full original representation cannot be received. For example, it should at least be possible to send an animation as a series of graphic images in fax format, to synthesize a



text message via the audio channel, or to send a series of annotated still images instead of a full-motion video film.

Standard and platform implications: A set of media format conversion tools that draw upon a rich set of basic techniques, such as speech recognition, speech synthesis, optical character recognition, hand-writing and gesture recognition, and frame sequencers are available. As the diversity of the systems on a network increases, so does the need for format conversion tools. The actual work settings could give an indication of which tools are most appropriate.

#### ■ 6.2.1.10 *Open system architectures*

The original Picasso concept was based on the architecture of PICA, a stand-alone personal information and communications appliance that necessarily had its own editing tools. Experience with the first Picasso prototype taught us the need for and advantages of an open system architecture. We found that users preferred their own tools for editing text and graphics to the primitive editing tools offered by Picasso 1.0. Users should be able to use their own favorites. Users also wanted to be able to move around flexibly and use alternative ways of getting work done. Our communications appliance model was not appropriate.

Standard and platform implications: It is important to be very careful about platform specifics, because these comprise a set of metaphors and conventions that can be very persistent. With our prototypes we observed that some participants had problems in learning basic Macintosh conventions—conventions we took for granted. A multimedia communications device should be designed with an open architecture to provide access to other tools on the same platform. Guidelines, like the Apple's Human Interface Guidelines for the Macintosh, should be respected, but adherence should be carefully weighted against needs of the communication device and the experience of the intended audience.

#### ■ 6.2.1.11 *Mail broadcast*

In Picasso 2.0 we incorporated a uniform mail notification function, but the challenge is to get the user's attention when new mail arrives. This could only be done when Picasso was the active application. There needs to be an integrated mail broadcast function that signals new mail independent of the application the user is in. This function could be broadened to include feedback on outgoing (or scheduled) mail, particularly mail that has not been successfully sent, especially

in the case where the user has to take action. (For a general discussion, see Status Feedback.)

Standard and platform implications: An integrated mail broadcast function requires a multitasking environment, or at least an environment where the active application can be interrupted. Various implementations of such a function already exist on many different platforms. The mail broadcast function should capture mail from multiple media, not only text, graphics and fax, but also audio, animation, and video from voice phone, voice mail, and videophone. In addition, the user should be given a clear and precise feedback on the queue of all scheduled mail, and cases where the user has to take action should be highlighted.

#### ■ 6.2.1.12 *Crystallization tracking and guided tours*

When people learn a new piece of technology, they learn certain patterns of use of the technology, a repertoire of procedures that the learners consider successful. This repertoire of procedures may not be considered optimal from the designer's point of view, but users feel comfortable with it since it works for them. We called this phenomenon—when people will not try to optimize a procedure which works to perform a particular task—"crystallization of patterns of use" (see section 5.1.2.3). For example, in Picasso 2.0, one participant found a very elaborate way of faxing someone a paper document. In another case, one participant knew how to send files only if they showed up in the default file selection dialog box. When she wanted to send a file from a floppy disk, she had to copy the file onto her hard disk.

Standard and platform implications: By keeping track of patterns of use, it may be possible to recognize certain forms of crystallization. Guided tours could then show alternative ways of doing things and help users step across various barriers or thresholds. It is not easy to recognize the intentions of users, but we believe that some plausible inferences can be made which form the basis of selecting appropriate guided tours. A tool to track "crystallization" should be implemented system-wide, since any system action might be a relevant component of task procedure.

### 6.2.2

#### **Picasso 3.0**

Based on the issues and implications described above, we outlined the functionalities, designed an interface for, but did not implement Picasso 3.0. By

explicating key points of our design in this section, we hope to show how we addressed some of the issues that arose in the course of our research with the first two prototypes.

We envisioned Picasso 3.0 as a group communication tool on a multitasking machine connected to a multichannel network. We focused on sharing information, that is on communication in the broadest sense. We maintained the mailing label metaphor used in Picasso 2.0 as the metaphor for communicating with somebody. We present this description as if Picasso 3.0 had been fully implemented.

Picasso 3.0 opens like a desk accessory on a Macintosh to present an initially empty, resizable window, called a shared window (fig. 6). The control field contains a mini mailing label with buttons to establish new connections, status information of machines currently connected, and information on the participants.

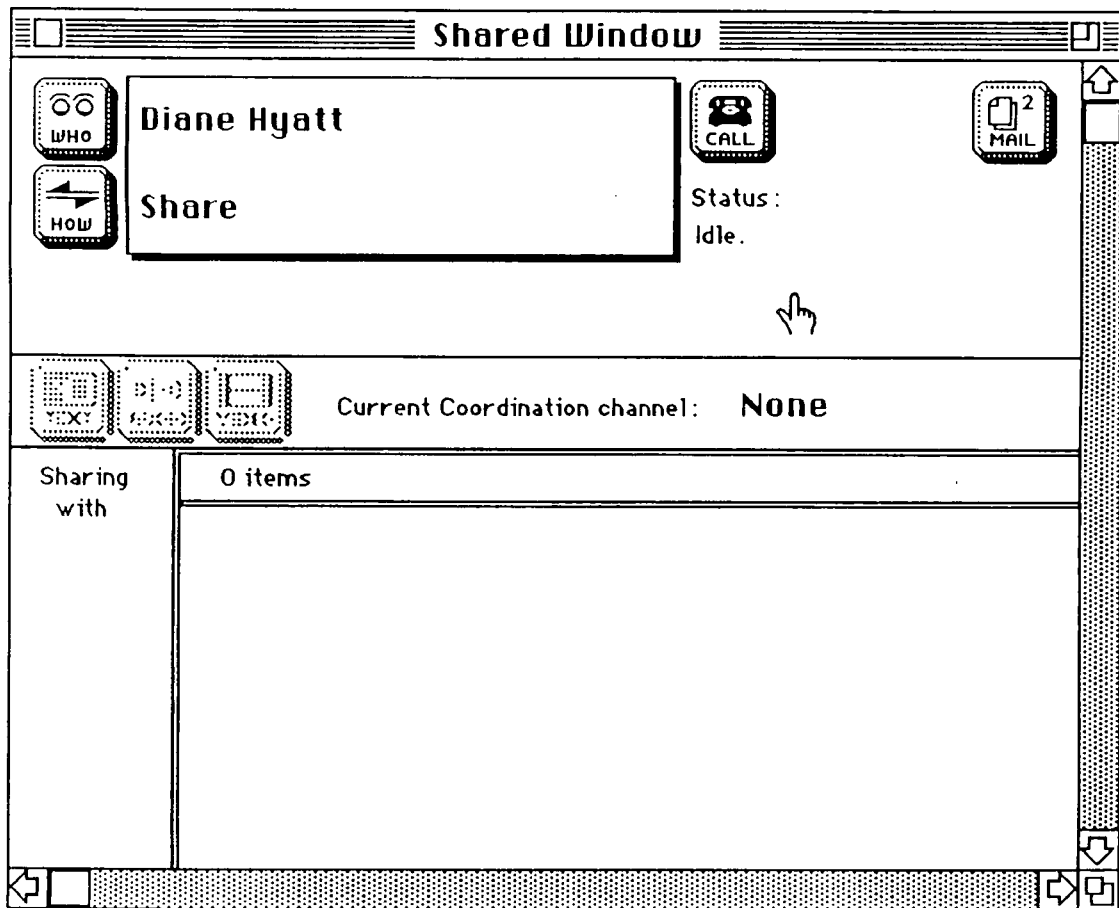


Figure 6: Picasso 3.0 initial Shared Window

The mailing label consists of three slots, with corresponding buttons. The Who slot lets a user select one of multiple names, since Picasso 3.0 allows multiple participants to communicate. The What slot (see fig. 7) can also contain multiple document names since more than one document can be sent at one time. The How slot allows the user to send information (fax or file through a dead link) or to make contact with someone (sharing information through a live link). Information is sent as a background process; the sender can continue with other computer-based activities, as soon as the send command has been issued.

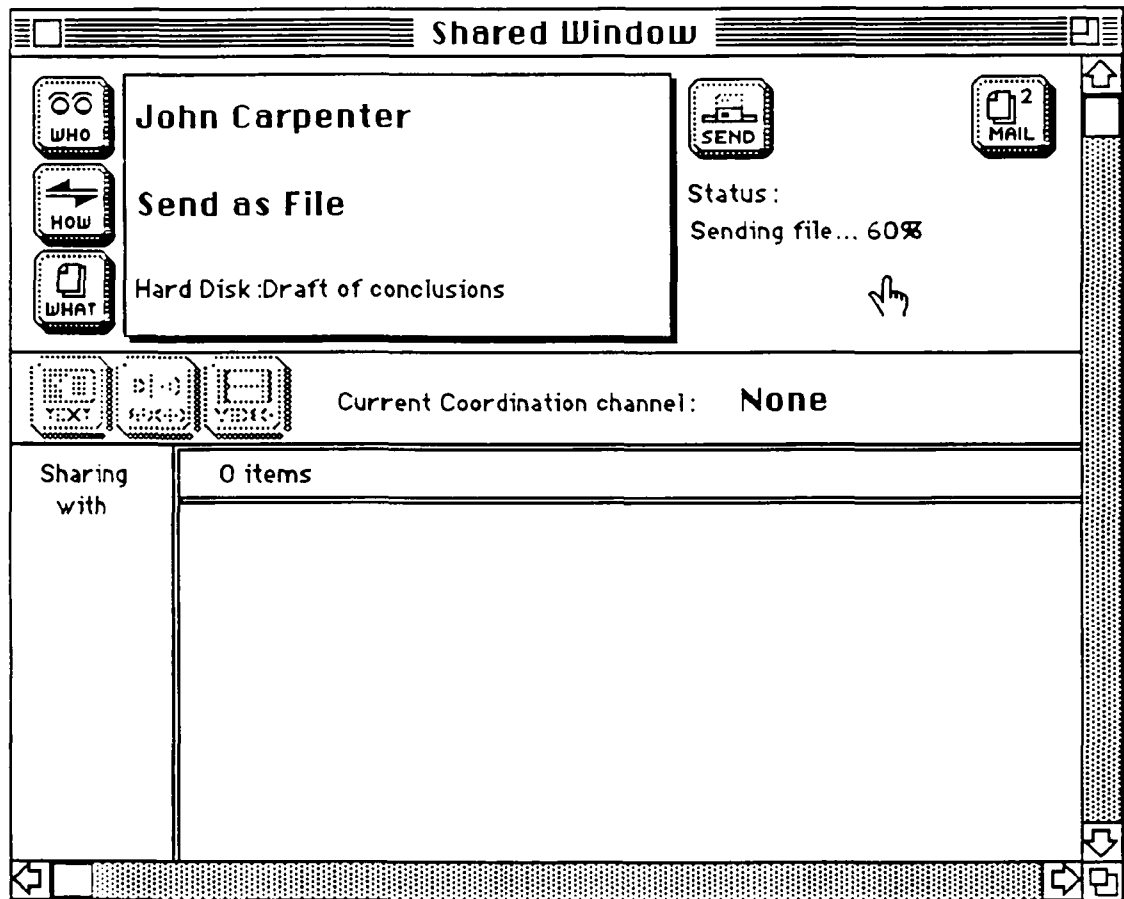


Figure 7: Picasso 3.0—Sending information in the background

The Mail Box button, always present in the shared window, provides instant access to all incoming mail, sorted by date, or sender as the recipient prefers. When clicked, a window opens that contains all mail documents. The Mail Box button remains on the desktop even after the shared window has been closed.

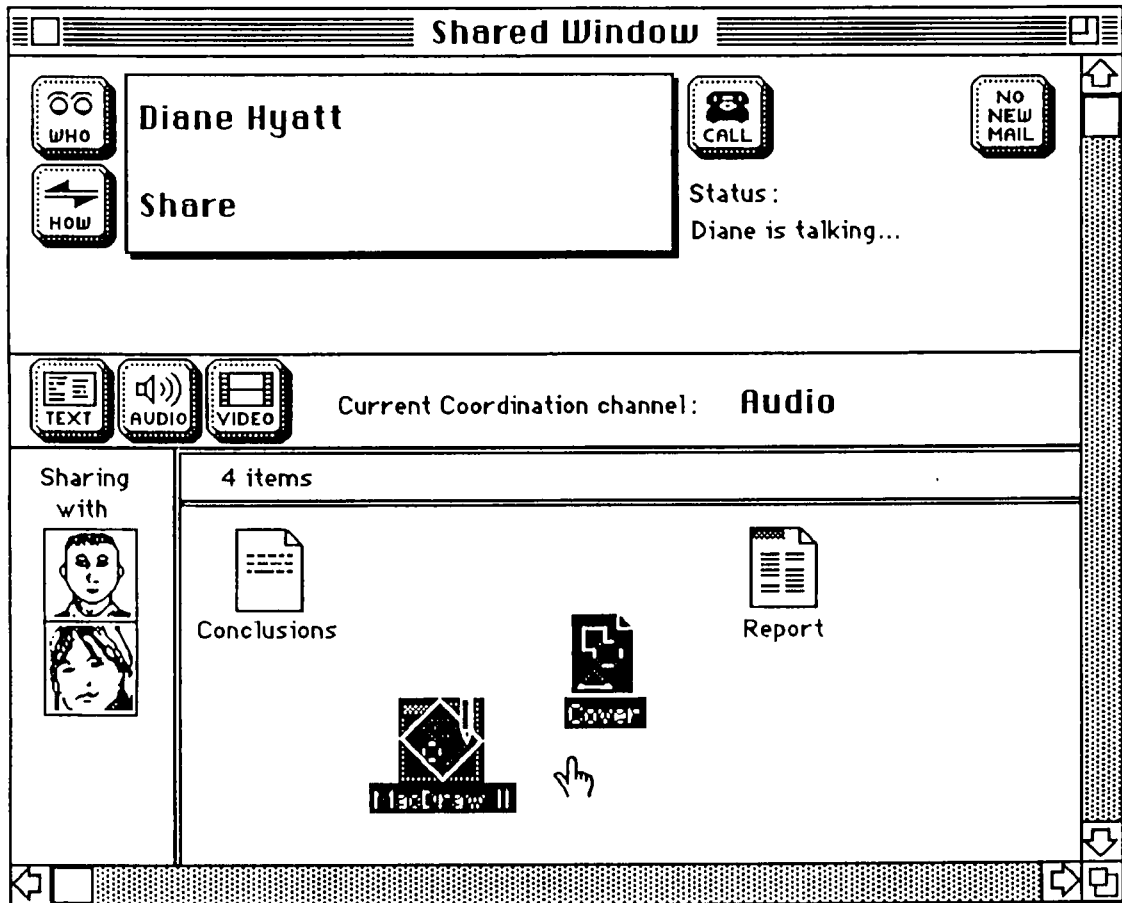


Figure 8: Picasso 3.0—Sharing information

The basic form of communication is to establish a live link by calling someone (fig. 8). The user selects the type of coordination link (i.e. text-, audio-, or video-link) from the How list. This action opens a shared window on each of the participants' screens and establishes parallel links between the shared windows. (A user can decide not use the shared window at all, but only use the live link established via the coordination channel. In case of an audio channel this would just be like a telephone conversation, in case of a video channel this would be like a videophone conversation.)

To address the difficulty of identifying participants, which we discussed in section 6.2.1.3, during a live-link communication a list of pictograms of currently connected participants is shown. Their images are color bordered or their names have distinctive fonts. The images are animated as soon as that participant

performs a communicative action, for example moving the cursor, bringing in new information, manipulating shared information, beginning to Chat, or beginning to talk. The image is replaced by a full-motion video if the coordination link is set to video. Participants have their own cursor to move around in the shared space, with each cursor in the same color as the person's corresponding pictogram frame.

To mimic the process of bringing materials into jointly shared physical space, a user can bring (i.e., "drag") pieces of information (files, icons, applications, etc.) into the shared window. Dragging things out of the shared window will either cause them to be sent (by someone who is not the owner), or marked as private (by the owner). All participants can open, edit, copy, cut, and paste pieces of information from shared files, run shared applications, and use shared tools and utilities. The information will physically reside on the owner's machine, so the shared window offers a view of a virtual machine. Copying a piece of shared information to private space causes that piece to be sent over the line. (The rationale behind this approach is to minimize data transfer over the line and preserve a form of ownership. An alternative would be to have a separate machine where all shared information resides, much like a file server with an advanced interaction link. Shared information could be stored permanently on that machine. Participants could connect to this machine to manipulate shared information, using shared windows in much the same way.)

The shared window is accessible although no connection has been established. This allows users to prepare for a communication by dragging in items to be shown to participants. It also allows a participant to make items available to others, so that others can have access to that information when the owner is not present.

A shared file's properties are conserved. To handle differences in environment, automatic format conversion takes place. But the type of default conversion should be negotiable, either through preference settings, or more advanced interactions. A self-launching document can be sent, if an appropriate application is not available, or if limited access has been imposed on the document (see section 6.2.3.1).

To print a shared file, the printer image is sent over and printed on the recipient's machine. Depending on the amount of data that needs to be sent, the original file can also be sent and printed if that is less demanding.

Shared applications run on the owner's machine. Each participant, if granted execution privilege, can issue commands. New files created by the shared application are stored on the machine where the application resides, and shared instantly by all participants. Only shared files can be opened, and when opened are copied to the application's machine. Private files must be shared before they can be manipulated by a shared application.

The coordination channel is always active during sharing. This is the channel to resolve ambiguity and synchronize cowork among participants. The default channel could be an audio link, a video link, or a text-based link. It should be possible to negotiate changes in coordination channel instantly. To coordinate a live link with a text-based channel, the Chat conventions need to adhere closely to established phone (or face-to-face) communication conventions. An improved Chat link should be a character-based, rather than buffer (line, or record) based message exchange, to provide instant feedback on message formulation. We believe that by exposing gaps and overlaps explicitly, it is possible to avoid unsynchronized messages, by determining whether there is activity on the other end. Messages would appear in a scrollable window, with synchronized panes, one pane and one font for each participant.

Closing the shared window causes all live-link connections to be closed. Closing makes private any previously shared items. Sharing amongst continuing participants remains intact.

■ 6.2.2.1 *Representation of levels of privacy*

Ownership of shared documents should be made explicit, either visually through a color scheme or name tags on top of the iconic representations or through auditory feedback, by using the owner's voice, for instance. Any piece of information that is brought into the shared window is, by default, totally shared by each participant. We envision levels of sharing (access privilege) achieved by bringing read-only (view-, play-, or print-only) copies into the shared window. Again, the type of access privilege should be visualized by labeling or the use of color in the iconic representations. A negotiation facility, supported via the coordination channel or via on-screen dialogs, could be used to change the access level on a certain piece of information. For instance, if a participant can view a shared file but not copy it, a permission protocol like the following could be activated as soon as one tries to drag the file to private space:

Is it alright if I copy this file?



The possible responses "Yes," "No," and "No, but . . ." would appear on the owner's machine. Responding in the affirmative or negative would grant or deny copy privileges. When responding with the elaborated negative "No, but . . .," a text field pops up where the owner can elaborate on his or her reasons or offer another form of access privilege, which gets sent to the requestor. (We assume a keyboard- and mouse-based interaction here. But the interface of buttons and text fields could well be replaced by or mixed with a speech interface, employing speech recognition in a very restricted domain, with speech synthesis or just a form of voice mail.)

#### ■ 6.2.2.2 *Variations on shared space*

Each activation of Picasso could create a new shared window. This would offer multiple, multiparty collaborations or conferences. If a shared window were active (i.e. open) all the time, without a live link connection, it could be merged with the mailbox metaphor. Sending information would mean dragging it with a mailing label attached to the shared window. The recipient would receive an update of his or her shared window. This would show the file icon along with an additional (e.g. auditory) notification. Participants would only see information "mailed to" them; information sent to or shared with others would be invisible. The information need not be sent until the recipient dragged it out of the shared window, which would be a way to filter incoming material efficiently. In a multiparty network, sender information could be attached on the file (either as an elaborate Get Info message on the Macintosh, or as an instantly visible label on the visual representation (icon) itself). The file could automatically be removed from the shared window as soon as it has been opened (read, copied), which would be an efficient way to acknowledge that it has been received.

### **6.2.3**

#### **Standard and platform requirements**

The above discussion shows that multimedia communications devices make high demands for network capabilities, multitasking, support of distributed processes, window systems, and audio and video input/output facilities. In this section we gather together the requirements for computer and networking standards and platforms.

#### ■ 6.2.3.1 *Requirements for window systems*

To support screen sharing and remote control in Picasso 2.0 we used a form of computer sharing that required users to share everything on their screen (or machine). Computer sharing can be implemented in hardware, as for example is done in Capture Lab (Mantei, 1988), or it can be implemented in software such as Farallon's Timbuktu/Remote for the Macintosh or Microcom's Carbon Copy Plus for the Windows platform.

To offer access to both shared and private files and applications we need a more refined form of resource sharing, which essentially requires a different interface between applications (and files) and the window system. One approach is to develop special-purpose applications, often called "groupware," that are designed for simultaneous use by multiple users. Grove, a group editor developed at MCC that allows multiple users to edit different parts of the same document at the same time (Ellis, Gibbs & Rein, 1991) is one example. Another is the Colab system developed at Xerox PARC (Stefik et al., 1987a), an experimental meeting room where a shared workspace is made visible on a large projection screen as well as each individual workstation. Colab offers different tools for different meetings, such as Cognoter for brainstorm sessions, and Argnoter, an argumentation spreadsheet for presenting, arguing, and evaluating proposals. Because of the significant programming efforts needed to write the new applications and the discontinuity with existing single-user applications, we do not promote special purpose multiuser applications.

Another approach is to execute existing single-user applications in a shared window. This is what Lauwers and Lantz (1990) have called collaboration-transparent applications. The Picasso 3.0 conceptual design promotes this form of sharing, limiting the impact on existing applications. The general problem then is the so called "floor control" for the shared window: who can control which shared object, when, and how? It is our goal to support spontaneous interactions. We envision multiple cursors, one for each participant, which can be moved around in the shared window to point at shared objects. Different participants are permitted to interact with different shared objects at the same time. Each shared object can, however, only be manipulated by one participant at any one time. Because potential conflicts can result in "mouse wars" or "keyboard wars," and may lead to data corruption, we would implement a first-come-first-served mechanism to handle simultaneous input. Access to shared objects can be negotiated, however, by participants via the coordination channel using

traditional social protocols. We prefer this approach—almost a running "open floor"—to more rigid floor control mechanisms. To prevent permanent data corruption, the window system should provide mechanisms to enable recovery from conflicting input.

The control of multiple-coordination channels depends on the number of channels that are available per medium per participant. Currently we envision one active coordination channel per participant (pair) connection, which is either audio, video, or text based. All responses from participants are passed on at any time, without any noticeable delay. Outgoing messages are directed to the chosen participant only. If channel capacity and availability is restricted, a more sophisticated communication channel manager will be required to support channel multiplexing and manage line conflicts.

#### ■ 6.2.3.2 *Coupling among shared windows: WYSIWIS issues*

Screen sharing in Picasso 2.0 enables participants to look at the same images and to establish coreference of common objects. At one test site we observed some problems with screen sharing that originated in different screen sizes. One participant had the full page of a document up on her two-page screen. The other participant, who was controlling that screen, saw only one quarter of the screen at a time on a much smaller SE screen. While one was discussing details on the top of the page, the other was looking at the white bottom half of the page. It took the latter a while before she was able to scroll to the top, and even longer before she had an overview of the page being discussed. In Picasso 3.0 similar problems can occur with a resizable shared window and different monitor screens. We could offer a standard view to the shared window according to the smallest screen among the participants. But we would not want to limit the ability of participants to organize the position and layout of the shared window to their personal preferences. In a network environment with different workstation monitors, true identical views of the shared window, also called "What You See Is What I See" (or WYSIWIS for short) coupling, is hard to achieve. Other research on multiuser interfaces indicates that strict WYSISIS is not even a desirable property (see Stefik et al. 1987a, 1987b).

#### ■ 6.2.3.3 *ISDN*

We have also pointed out the need for a coordinating channel with known conventions as a mediation channel for planning collaborative work. Such a

second communication channel should be an integral part of a Picasso workstation. This is a powerful argument for (two-channel) ISDN: A phone line is needed to negotiate who will connect to whom, to keep mutual work interaction coherent and synchronized, and to augment what the activities on the other channel are. There is a significant need for a communication-channel manager (see section 6.2.1.7). ISDN also provides higher-bandwidth communication channels than the current telephone network. Higher bandwidth is crucial for reaching real-time performance for screen sharing. It is our estimate that 10 to 20 times the current bandwidth, 96-192 Kbps, is needed to reach real-time performance, but demands are even higher for audio and, particularly, full-motion video.

Future platforms for IMC devices should offer: multiple windows with different levels of privacy, quick choice of communication channel, minimal interruption of live-link exchanges, user-controlled resource management, adherence to existing communication conventions, negotiation facilities, broadcasting facilities, and self-launching documents.

Few of the existing platforms directly address these needs. Unix-based workstations, like Sun's SPARCStation2 and NeXT's NeXTCube, offer true multitasking operating systems. Top-of-the-line personal computers, like Apple's Macintosh IIfx and IBM's PS/2 Model 55SX, are moving in that direction with their operating systems—System 7.0 and Windows 3.0 respectively. The above-mentioned systems all offer LAN capabilities, which can handle ordinary file sharing (Jung & Webster, 1991). These computer networks meet the needs of media like text, graphics, and even audio, but the huge data-transfer requirements of video require a separate high-bandwidth network. Developments in optical-disk storage and fiber-optic cables, together with video compression techniques, should eventually merge telephone networks (ISDN) with computer networks and audiovisual networks.

#### **6.2.4**

##### **Picasso and the PICA conceptual framework**

The conceptual design phase of the PICA project at Philips Telecommunications and Data Systems—Advanced Development identified a conceptual framework which contained nine objectives related to the perceived needs of users. This section reviews these objectives and comments on them in light of our experience with Picasso. We discuss whether evidence for each objective was observed in

our video-data or whether each can be justified by our findings. We will also discuss how each of these needs relates to the design implications for Picasso. The nine Pica objectives are:

- Groups of functions
- Multitasking
- Expressive range
- Evolution of conventions
- Personal models of space
- Shared spaces
- Communication process range
- Evolution of use
- Personal choice according to models of use

■ 6.2.4.1 *Groups of functions*

PICA objective: To support the need to physically and conceptually connect related sets of functions into meaningful categories of tasks and to perform these functions in the most appropriate mode

From studying Picasso 1.0 in use, we came to understand that Picasso is primarily a tool to communicate, not a stand-alone document processor with communication facilities. Accordingly, we divided the functions into three major categories: those directly related to the actual communication, those to prepare for the intended communication, and those to check the incoming mail. The fax function, however, posed problems at one test site, where the participants were not familiar with faxing from a computer. Unlike ordinary fax machines, the computer-supported fax procedure is split into a scanning part and a sending part. The first one was in the "prepare" category while the second one was in the "communicate" category. Partly because of their unfamiliarity with the notion of a file in general, it took them some time to realize that the link between the two was a scanned document, a file that could be faxed. At another test site, one participant was initially confused about conversion steps she thought were needed before sending a file. The confusion was probably based on her prior exposure to the fax format limits in Picasso 1.0, which required text and graphics to be converted into a standard fax format.

The Picasso research thus supports the value of the PICA objective. It also suggests that what counts as a "meaningful category of task" for users actually

emerges from their actual work practices. It can not be fully defined *a priori* by designers.

#### ■ 6.2.4.2 *Multitasking*

PICA objective: To support the need for the user and PICA to simultaneously perform multiple tasks during a communication act

Our data show that it is very important to minimize interruption of ongoing live-link exchanges. We also noted that there should be a dedicated channel to coordinate, augment, or synchronize communication at other channels. It should also be possible to perform other tasks flexibly, without disturbing the ongoing communication. All these needs require a multitasking system that can support background processes to set up communication links, provide clear feedback if a communication link fails, broadcast incoming mail messages, and support multiple channel communication.

Again, the Picasso research thus supports the value of the PICA objective, and extends it by indicating one necessary part of the organization of these multiple tasks.

#### ■ 6.2.4.3 *Expressive Range*

PICA objective: To support the need to embed direct and indirect (gestural) expressive messages with communication

We observed difficulties in establishing coreference—that is, establishing ways to refer to, annotate, or point to objects or features that are of interest. Before we introduced the screen-sharing facility, participants spoke on the phone to refer to document contents or machine details. After we introduced screen sharing, we saw a richer use of coreference, since it was possible to look at the same thing while talking about it. During one session, one participant said to her partner describing previous problems of coreference:

Well that makes it real clear, you know,  
talking about tops and bottoms and sizes.  
Boy that was a real puzzle.

This suggests that the users came to understand the way the screen-sharing functionality can assist in establishing coreference, and that they found this

assistance valuable. In another session, the same participant controlled the other's machine and demonstrated how to use a Macintosh utility to manage a large set of fonts. Over the phone she explained what she was doing, but she made gestures with the mouse to refer to icons, and other elements on the screen. These mouse gestures could be seen by the participant whose screen was being controlled, thus allowing more detailed coreferencing than just looking at the same complex screen would permit.

Gesture is often thought of as "expressive"—adding an emotional component to the propositional content expressed by language. As these examples show, however, language has a strong deictic component; that is, speakers use the actual speech situation as the referent for terms like "here and there," "up and down," "top and bottom," etc. The gestural functionality provided by Picasso was used to help establish coreference. This is not merely an expressive function, but part of the central referential function of language. This use of gesture is even more important to support than an expressive use.

#### ■ 6.2.4.4 *Evolution of conventions*

PICA objective: To support the need for individuals to jointly negotiate the rules, conventions, and practices of communication over time

The Picasso participants very frequently used a separate telephone line to augment and coordinate their ongoing Picasso communication. In general, people need to coordinate their work, and they rely on a channel with known conventions to keep the mutual work coherent. This becomes an issue which requires the attention of both users and designers in situations that offer a choice of channels for use, at least some of which do not have well-established conventions. Because of this, we incorporated a coordination channel in our specifications for Picasso 3.0. This would explicitly permit such negotiation of conventions and practices.

We also observed a situation where the Chat tool was used by a group whose members took turns typing messages. This confused the person at the other end, since the person typing is not required to provide an identification. This example shows the problems which arise when people use a communication tool whose conventions have not yet been established and which can not be immediately inferred from the conventions of known channels.

In this kind of situation, participants could develop an identification convention such as typing an introduction statement explicitly. It is also possible for the designer to build in a facility to allow easy identification for each participant (although the use of such a facility should be optional). New conventions can evolve after the introduction of new technology, as has happened with verbal communication around the telephone. But the technology should not require interactions which violate established social conventions of communication. An example of such a violation is the problem in Picasso 2.0 with sending files and faxes, where the delay in sending and the fact that the machine could not be used during sending strongly violated the ordinary timing of work sessions.

■ 6.2.4.5 *Personal models of space*

PICA objective: To support the need to build a mental model of a physical or conceptual space in which communication and information handling may comfortably take place

Obviously, it is preferable to produce a design that users can understand, rather than one which they must learn and use by rote. The issue which this PICA objective raises is how to study and represent such understanding. One method is the postulation of individual mental models, an approach which has received a great deal of attention in cognitive science and psychology in the last 25 years. We will not comment on this body of work here, since the method of the Picasso research has been to focus on a different area—that of the social construction of understanding. Our video analysis allowed us to investigate how people use a device and how they explain it to others. This allowed us to determine whether they are able to do their information-handling comfortably, without needing to postulate mental models.

We observed many problems in learning basic Macintosh conventions—conventions we took for granted like the notion of files in folders and the file hierarchy in general; navigation through the standard file-selection dialog box; switching from Finder to MultiFinder which results in a different view of windows and desktop icons; and the difference between single- and double-clicking. Nonetheless, it would be very hard to reconstruct or validate any mental model that an individual might have of the system, or even parts of it.



#### ■ 6.2.4.6 Shared spaces

PICA objective: To support the need to build a mental model of a space in which communication takes place and in which the people involved perceive a balance between privacy and community

The notion of sharing has very explicitly been addressed in Picasso in the form of screen sharing. This deserves critical attention as our discussion in the previous section indicates. Options for sharing should be much more fine-grained than merely screen sharing. Sharing should be based on windows, files, or any entity that is an identifiable information unit for the participants. The "balance between privacy and community" that PICA calls for should not be a set of predefined and preconceived settings and relationships for privacy determined by the designers. The balance (i.e. the amount and the nature of the sharing) should be negotiable between the participants, such that each participant is comfortable with it, and that it meets the needs of the tasks at hand. This means that it should be easy to move material into and out of a shared space and easy for an owner to change access privileges dynamically at any time. (See our discussion of Picasso 3.0, section 6.2.3.)

Again, in this instance, the Picasso research extends the PICA objectives to make the categories emergent rather than *a priori*.

#### ■ 6.2.4.7 Communication process range

PICA objective: To support the need for tools that address your needs at every stage of the communication process

In the course of the project, we moved from the closed, stand-alone Picasso 1.0 prototype to the open Picasso 2.0 prototype, which allowed access to any text and graphics editing tool. We found that users wanted to be able to use their favorite tools, even if very advanced tools are offered, to prepare whatever they were working on. Picasso should primarily be a communication tool, which can be accessed from within any other tool. Both the needs, and the stages of the communication process must be determined by the users, preferably as they negotiate their preferred work practices. In this sense, Picasso 2.0 was designed to be as nonmodal as possible. This required an interface that centered on a single file format and file storage structure. Files were created using a number of hardware devices and software programs, but all were stored together, not

sorted by type. Thus, the communications interface was greatly simplified—it only had to support the transmission and reception of existing documents, rather than to help the user create them, delete them, or organize storage.

■ 6.2.4.8 *Evolution of use*

PICA objective: To support the need for usage to grow organically in response to the pace of change in the surrounding circumstances

The actual design method of the Picasso system, Reciprocal Evolution, at a global level of tight design and observation loops between users and the product designers, responded continuously to the participants' needs. At a much more local level, Picasso supported the growth of the user community by allowing transmissions to and from ubiquitous devices such as fax machines and by taking advantage of the standard file structures and software and hardware standards of the existing platforms. Therefore, people without Picasso can still come to participate, learn, and work within the community of users.

■ 6.2.4.9 *Personal choice according to models of use*

PICA objective: To support the need to combine, arrange, and access functionality in a way that is natural and comfortable, based on what you do and how you do it—suggesting both a personal and a group dimension

Our research suggests that this is indeed a real need for users. We observed that participants did speculate about the natural use of functionality. For example, at both sites, users speculated about what the use and value of the Chat functionality might be. They were rather skeptical, arguing that it had no more value than the telephone or joking that it might be useful if they had laryngitis.

This shows that the category of naturalness of a functionality or a group of functionalities is an appropriate one. There is an additional point, however: Users were not always right in their speculations about what they would naturally use. In fact, all the users did find a use for the Chat functionality. This argues that one can not take users' comments, either to one another or to designers in an interview or focus group as a final judgement about the naturalness or usability of functionalities and groupings. Studies of actual use are also required.

To summarize this discussion, in general Picasso data supports the validity of the PICA objectives. At the same time, the PICA objectives appear to assume preexistent categories such as "meaningfully connected categories of tasks" or "users' communications needs." In contrast, our Picasso work showed that in general, users' needs and models were not preexistent, but emerge from actual use of technologies in real circumstances. Indeed, one of the more surprising findings was that even when users appeared to have plans for how they would use the new technology, the actual uses they made of it were quite different.

### **6.3: Reciprocal Evolution and the corporation**

The Picasso Project allowed researchers from Philips and IRL to address questions such as "How is new technology adapted in the world; how does it become transparent; how does it get enculturated—becoming a natural element in the culture in which it is used?" Although it is rather unusual in product development environments to talk in terms of "enculturation," IRL's learning research suggests that this is a central notion in understanding the introduction of new tools into ongoing or new activities (Lave, 1988, Collins, Brown, and Duguid, 1989).

It is our contention that these three key concepts—activity, culture, and tool—form an interdependent and inseparable complex which continually evolves as new opportunities, new uses, and new technological possibilities emerge. Thus, both the methods and the findings of the Picasso Project have implications for how corporations like Philips think about their markets and how they organize their product design and development cycles.

In this section, we review the approach of Reciprocal Evolution in this light and discuss its implications for the strategies and activities of the corporation. In particular, we explore the importance in this context of:

- studying real settings and real users
- interdisciplinary and interdivisional efforts
- early investigation and long-term studies
- changing the design of the product and the organization
- changing the basis of corporate long-term planning

### **6.3.1**

#### **Studying real settings and real users**

The Picasso Project recognized the necessity of obtaining ecologically valid data. Laboratory observations of subjects exposed to a new technology are no substitute for long-term observations of the real activities of real workers using technologies in their own complex work environments. While there is inevitably some value in aspects of laboratory experimental science—in particular in studies in ergonomics, vision, and audition—the lessons learned from such investigations are only a piece of the much larger puzzle of how human beings relate to technology and give it meaning in their daily activities. Even these experimental studies may be invalid if they are based on ungrounded assumptions about what the workplace must be like, rather than on actual observation of the workplace. Moreover, the more fundamental questions—how markets are encountered and how they evolve in the moment-to-moment particularities of human interactions in real social groups, organizations, and communities—cannot be answered in the lab.

Viewing technology adoption as an issue of learning provides an important perspective on why the laboratory perspective is inadequate. Most people learn a new technology because they want to use it to do their own work, not because they want to master the technology. They recognize a gap between their needs and the current structure of their technical world and they hope the tool can help narrow that gap. To find out, they struggle to connect the tool to their work tasks, often improvising new uses in the process.

Designers, however, tend to think in terms of explicit functions and of naive and expert users. They do not contemplate the unpredicted uses or the very wide range of users, each of whom may benefit from very different design and support facilities. To understand this field of people and practices, designers cannot simply imagine what users do; they must go out and observe them. The way users use a technology is never just an incomplete version of expert use. There is often an integrity and unexpected success in the use patterns that a user has evolved for tools in his or her community.

If designers cannot imagine, laboratories certainly cannot recreate the complex conditions of workplace learning as it is lived. As we have shown, workers learn not in isolation, but amid other tasks, ongoing responsibilities, multiple conversations, and the participation of coworkers who move in and out of the

learning process. Thus learning of a new technology must be feasible in these sorts of settings—indeed it must be designed to take advantage of them, just as workplace learners do.

In contrast to imaginative speculation or the creation of special, hermetic environments, a core aspect of our method has been to videotape and study real work sites, both before and after the introduction of new technology. We videotaped a series of work sessions at our participant sites, and then analyzed the interaction.

Analysis did not begin with an *a priori* set of categories, whether from social science or design theory. To do this would mean to assume that we already knew what was important in the participants' work practice. But we wanted to understand users' emergent practice, which was not at all predictable from either their existing work or the design specifications of the tools they are using. We wanted to know what beliefs, concerns, and practices evolved as practitioners sought to make their technologies, their work, and their organization align. We wished, with our participants, to make sense of their work and technology as lived practice.

As the project progressed, we focused on how equilibrium states were reached in levels of expertise in the use of these technologies. This led us to explore how people come to know where to go to for help, to recognize who is expert with various aspects of the technology, or to sense who can help to fix problems. And we examined how this emergent expertise is integrated or excluded from the institutional view of expertise.

None of these questions can be answered in laboratory study. We had to look at the social mechanisms, the communities of practice, and the crosscutting relations of power, authority, and expertise. In particular, we looked at the readjustments in standard practices and relations that result when new contributors or new technologies entered a community. And because the method takes into account these interrelation of technologies, practices, and organizational structures, its results, we believe, can provide important insights not only into product design, but also into organizational design, and corporate planning and strategy.

### **6.3.2**

#### **Interdisciplinary and interdivisional efforts**

The Picasso team members brought varied experience from design, social, and cognitive perspectives, which together enriched the project results through an important collaborative process. The process of examining the data in the company of colleagues from different disciplinary background was invaluable. Thus, a central lesson we learned from the Picasso project is not to modularize the team.

Our conception of this sort of interdisciplinary, interdepartmental research team has broad implications. It is not enough for researchers to study users and inform the designers, as in a traditional linear model of the relations between research and design. It is from the multiple perspectives on the same data that insights and interpretations about the meaning of users' work practices and consequently responsive designs emerge. Thus, ideally every group involved in product development—from marketing, to design, to engineering, to sales—should be involved in the process of determining what it is that people actually do with products.

In the course of the project, we came to recognize that the sort of data we were using was ideal for simultaneous consensus building, reflection, and design for exactly this sort of interdisciplinary team. Video records can provide a common focus for the diverse expertise of researchers and designers. It can also afford a basis for far more meaningful conversations with work practitioners than abstract, written descriptions (see Suchman & Trigg, 1991). Moreover, it can also provide continuity. In large, long-term projects, especially where people join and leave over the years of development, too often fundamental assumptions and continuity can be lost. Video material collected during different stages in a project and the written traces of its analysis help both to shape and to propagate shared ideas, forming anchor points for conversation, discussion, and design.

### **6.3.3**

#### **Early investigation and long-term studies**

The Picasso team also concluded that the study of work practices with tools in real work settings must be part of a long-term process of inquiry. These investigations need to be pursued over a protracted period, starting before the

introduction of new technologies to a work site, so that the observations of transformations of work practice can have a baseline for comparison.

For corporate product development, it would be helpful to begin working this way even at the concept-development phase so that future users of a technology can be involved as early as possible. (Currently, where future users are involved in concept development, their participation is undermined by the impoverished laboratory-like or focus-group methods of study.) This phase could then form a departure point for development; workers and designers could engage very early on in significant joint envisionment of work tools in the contexts of work practice.

The best way to implement a Reciprocal Evolution system in the process of product design would be for a team of researchers to participate in the change process over the course of a significant number of years. This would involve increased involvement of the relevant groups in the corporation as they work to develop and design advanced technologies. This process departs significantly from the current compartmentalized groups in the linear model of product development and design we see today. But it should result in a more dynamic and innovation-sensitive organization.

#### **6.3.4**

##### **Changing the design of the product and the organization**

One purpose of studies of work practices is to produce more learnable and useable technologies for real work settings. In the Picasso Project, we also sought to develop a method that would help understand what users make of design innovations. Our conclusion here is that *use is design*, and that innovative uses that workers make of a product (or decisions they make to ignore what designers think of as innovations) can give crucial information about what the next version of that product should be, or what new tools would be desirable in the workplace.

This conclusion has important implications not only for product design, but also for product support. Support services provide corporations with an opportunity to investigate and understand what users have made of the technology in their work and a chance to see their products in use. Thus, instead of responding on the assumption that the user has fallen short of the designer's expectations, the corporation's product-support teams could profitably use these conversations for product and market research.

As part of this commitment to seeking an understanding of evolving design through use, there needs to be a corporate commitment to modular approaches to product development, so that insights from real users can be incorporated quickly into the next versions of products. This means developers should make use of rapid prototyping and high-level prototyping languages so that ideas can be tested with real users in real work settings well before new concepts become new products; otherwise the expensive manufacturing processes involved tend to make the perceived benefits of needed iterations in design seem small in comparison to the costs of retooling manufacturing processes and commitments.

### **6.3.5**

#### **Changing the basis of corporate long-term planning**

A further implication of the work of the Picasso Project is the need for long-term corporate product planning. This requires a shift in the conception of what research is for. Research of the sort carried out in the Picasso Project should be seen as an integral part in the whole design cycle of products. To be competitive in the long-term, a business should think of a single product not as finished entity, but as a punctuation point in an ongoing cycle of design. This involves learning to see what markets are emerging from the interpretations and adaptations of existing products by workers in their organizations. While standard market research and other forms of "probing" the user have rested on the same intuition—seek the future by looking at emerging trends and beliefs today—the nature their methods relies too much on reflection and abstraction outside the contexts of use, thus they miss much that is going on. Reciprocal Evolution, by contrast, is a research method directly located in the thick context of the workplace.

A corporation needs to be committed both to the technology and to the market, with market-driven plans for technical development in the long term, and with technological innovations widely tested in the market before long-term directions for a product line are established. This requires participation and support for these kinds of pilot projects from the very top. Here it is not the research community that needs convincing, but rather the decision makers in the product development and marketing groups in corporations. From an organizational perspective, the participation and support of high-level management is absolutely necessary.



#### 6.4 In conclusion

In closing, we may simply state that Philips and IRL have both learned a great deal from this unusual and innovative partnership. In collaboration with IRL, Philips has developed guidelines for technology design based on the real needs of users, and it has gained models and support for changing the way that the corporation approaches product design. For its part, with the help of Philips, IRL has been able to develop its method of Reciprocal Evolution of design, and to refine it in practice with workplace multimedia communication tools. IRL researchers have expanded their understanding of how learning takes place in the workplace and how research methods and theories may best be brought to bear to study it. In the process, IRL has demonstrated an ability to make research relevant to industry and to address the complex problems of learning in the workplace.

## Appendix 1: IRL THEMES

In section 2.5.2 we referred to the three IRL themes: glass box technology, social construction of understanding, and situated learning. The following extracts from IRL literature describes these themes as follows:

### 1: Glass box technology

A major contemporary demand on learning arises from the proliferating devices of information technology and the increasingly complex organizations in which they are embedded. These devices call for a difficult conceptual shift from the intuitive understanding of mechanical causality to, as yet, a far-from-intuitive understanding of information causality. And the functionality of these devices is now so diverse, that each, while offering tempting new functions, also contributes new learning demands. IRL's concept of glass-box tools embraces the idea that within much information technology, lies the technological potential for elaborate and sophisticated multimedia explanatory devices to support bootstrapping and learning and thereby to help to make a device in some way transparent to its users. At its most basic, transparency may be achieved by allowing the user to see "through" the tool to the familiar domain or task in which tool and users are situated. WYSIWIG word processors, for instance, allow users to see directly both the content and the format of the document they are composing, without needing to focus on the technology which supports it.

Despite the technological potential for supporting such explanatory approaches, the problems of transparency are not susceptible to a technological solution alone. Tools and tasks are inevitably and inescapably a part of a community of users. Opacity and transparency are, therefore, as much functions of the community and the communally understood tasks as they are functions of the device itself. The supports or bootstraps that enable beginners to haul themselves over the initial learning threshold of any device are not to be found in the engineering of the tool alone. They are distributed throughout the social matrix in which the tool is embedded. Support for continuous and unbroken development through and beyond the initial learning threshold needs to draw on the collaborative ways in which social task construction enriches the understanding of tools. This interplay between tasks and tools within a social connection is fundamental to glass-box transparency. In order to make a device transparent, therefore, a well-developed and principled understanding of the

social and cognitive aspects of learning and tasks is necessary. This is addressed in the other two major themes.

## **2 Social construction of understanding**

Learning and understanding—and, thus, related concepts like bootstrapping and transparency—are not aspects of individuals in isolation. Even when individuals work alone, the concepts they use are products of a deeply social, collective, constructive process and they are shared and distributed throughout communities, such as families, peer groups, neighbors, colleagues, and so forth. A person's grasp of conceptual knowledge is judged by his or her ability legitimately to use it, add to it, and share it within these communities.

Such a view of understanding throws a new and troubling light on conventional ideas about instruction, information exchange, and didactic teaching methods. Apparently direct methods of transfer, which assume knowledge to be some sort of transmittable substance, underpin not only Western education, but also the means that have been used to try to help people learn about technology. Directive documentation, on-line help systems, flip cards, digital displays, and the like, all reflect modified versions of this assumption.

But people do not act like vacant receptors of prepackaged information. They do not receive knowledge passively and abstractly. Rather, they construct their understanding actively and in context. Understanding is, thus, not received, but built in the course of purposeful activity, and in service of it. The understanding produced this way emerges out of, is embedded in, and is inseparable from the community and the activity. This need to construct interpretations and understanding needs to be seriously considered and honored in technology design.

## **3: Situated learning**

Closely connected to the theme of the social construction of knowledge is the theme of situated learning. Research into situation semantics, indexicality and similar concepts has shown that language is not wholly portable. Its meaning is to greater or lesser degrees dependent on and tightly connected to the situation in which it arises. "Can you, come here now?" needs a situation to frame its interpretation. Speakers inevitably rely on the embedding situation to enable them to speak or write in this and similar ways.

By extension, the embedding context also provides an integral part of our learning and understanding. Our interpretations of the world are heavily situated in the tasks in which they are developed. People use the physical, social, and historical context of the task as essential parts of the ultimate construction. Thus learning is situated in actual practice.

The situation, the social as well as the physical environment, plays a central role in supporting learning and may thus be used by technology designers to great effect. But the significance of the situation cannot be decreed; it cannot be limited just to particular features of the immediate environment; nor can it be universally defined. People focus on different parts of the context for different reasons and at different times. Nevertheless, although the situation may seem amorphous, and although it cannot be immediately defined or contained for instruction, it is important both for initial bootstrapping and beyond. In people's ability to make use of the environment and the structure of tasks, lies the possibility for situated bootstrapping, and in their ability to shift focus may lie the means to move from initial bootstrapping into more and more complex understanding as users focus on richer and richer aspects of the situation.

## Appendix 2 PROTOCOL CONVENTIONS

### Transcription Conventions

The following are the transcription conventions used in this report. They represent a modification of the Sacks, Schegloff, Jefferson transcription conventions currently in wide use, as detailed in (Maxwell and Heritage, 1984).

### Overlapping Utterances

When short overlapping utterances do not start simultaneously, the point at which an ongoing utterance is joined by another is marked with a single left hand bracket at the point where the overlap begins:

Tom: I used to smoke a lot.

[

Bob: He thinks he's real tough.

In the case of a long overlap, for ease of typography, // is used to indicate the point in the ongoing utterance where the overlap begins. By convention, the next speaker's turn in the transcript is read as the overlapping utterance.

N: So I erased it, // but because it was on the crummy fax paper I couldn't get it off

M: See I liked that. Well that's interesting cause I liked it I liked it with the smudging around it, it looked like it looked like you know an old cement stone wall of some sort.

## Intervals Within and Between Utterances

When intervals in the stream of talk occur, they are noted as [pause]. We have not followed the usual practice of timing such pauses, since many of our interactions are telephone interactions, taped separately at each end. The problem of synchronizing such separate audio streams makes any attempt at timing of pauses too inaccurate to be used for research purposes.

## Characteristics of Speech Delivery

Colons are used to mark a lengthening of the sound it follows.

But see, actually no:.

Bold type is used to indicate speaker emphasis.

When would we ever need to use **this**.

Quotation marks are used to indicate reading intonation in a speaker's utterance.

If you look at the left line down, where it says  
"Training for Business."

Brackets are used to enclose some phenomenon which the transcription does not fully specify. This may include uncertainties in the transcription, for which the transcriptionist offers one or more possible hearings. Brackets enclosing X's [XXX] indicate a portion of speech which the transcriptionist can not offer any hearing. Brackets may also enclose a description of gesture or action accompanying the speech, or non-linguistic vocal productions such as laughter, coughing, etc. Brackets are also used to enclose an initial used as an alias for an actual name used in the conversation.

### **Citation Conventions**

Underlines are used to indicate emphasis by the analyst, that is, to indicate the particular section of interest in a transcribed example.

John Maxwell and John Heritage (editors) Structures of Social Action: Studies in Conversation Analysis. Cambridge University Press. 1984

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## PICASSO TECHNICAL REPORTS & PUBLICATIONS

A series of technical reports and other publications relating to the Picasso Project is currently being written by the researchers. Some reports and publications are already available, and the remainder will be published shortly.

### Technical reports

- 1: **Picasso system design rationale.** John de Vet and Christina Allen.
- 2: **Design implications of the Picasso research: What would Picasso 3.0 look like?** Christina Allen, John de Vet and Roy Pea.

### Publications

- 1: **The reciprocal evolution of technology, work practice and basic research.** Christina Allen. (in press) To appear in D. Shuler (ed.), *Participatory Design*, Hillsdale, NJ: Lawrence Erlbaum Association, 1991.
- 2: **Linguistics in the loop: Contributing to the design process.** Charlotte Linde. To appear in Richard Frankel and Catherine Pettinari (eds.), *Talk at work: Applied linguistics research in organizations*. Cambridge: Cambridge University Press.
- 3: **The collective learning-by-doing of multimedia communication tools.** Christina Allen and Roy Pea. To be submitted to *ACM Transactions on Office and Information Systems*.
- 4: **Communication channel use.** Christina Allen and Charlotte Linde, in preparation.
- 5: **Social negotiation of attitude.** Christina Allen, Charlotte Linde, in preparation.
- 6: **Open state of talk and turntaking with activities.** Christina Allen and Charlotte Linde.